Maryland Guidebook For Marina Owners and Operators On Alternatives Available for the Protection of Small Craft Against Vessel-Generated Waves

Prepared For

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INTRODUCTION

This guidebook is part of an ongoing effort by the State of Maryland to assist the marine community in the development of functional marinas. It specifically addresses the protection of marina facilities and moored small craft from vessel-generated boat wakes. The guidebook was developed for marina owners/operators, and includes:

- General marina layout and design considerations
- Predicted vessel-generated waves for various craft
- Alternatives available for protection against vessel-generated waves as well as relative effectiveness, costs, and sources
- Federal regulatory requirements

The purpose of this guidebook is to provide general information on alternatives available that will result in reduced vessel-generated wave impacts in a marina, and therefore, a quieter, safer mooring area. It is not to be used as a design manual, but as a reference of guidelines necessary to plan for vessel-generated wave protection. These guidelines can be used during initial marina design or for modifications to an existing marina.

This guidebook may be revised from time to time to keep current with experience and advances in available technology.

Chapter One

BACKGROUND

THE PROBLEM

The State of Maryland has an abundance of water resources including a large portion of the Chesapeake Bay and numerous tributaries and rivers extending throughout the state (Figure 1). Many commercial and private marinas have been developed along the banks of these waterways. Along the Chesapeake Bay tributaries, in particular, marinas commonly consist of a vertical bulkhead along the shore with docks extending into the waterway for vessel berthing.

Marinas in tributaries generally have limited fetches (fetch being the distance over water in which wind blows) and typically do not experience large wind waves. However, these marinas are generally unprotected against and exposed directly to the wake of passing vessels navigating the waterway. Vessel-generated waves are a nuisance and can cause disturbances in marinas that result in damages to small craft and marina facilities.

The imposition of speed limits throughout the entire lengths of tributaries and rivers is not practical and causes conflicts with a broad variety of waterway users. Speed limits are generally imposed in congested areas only with consideration given to safety. The State of Maryland, Department of Natural Resources, Boating Administration, strives to achieve a balanced approach in waterway usage and recognizes that a need exists to inform marina owners and operators of techniques available to minimize or alleviate the undesirable effects of vessel-generated waves.

MARINA LAYOUT/HYDRAULIC DESIGN CONSIDERATIONS

Marinas are defined as small craft facilities for yachts and/or recreational vessels that are generally under 50 ft in length. They require sites that are well protected from wave action, as well as adequate land area for parking (Gaythwaite 1990). The ideal marina site would be one that is protected from wave action by natural features (such as a marina in an embayment). Where this protection is not provided, artificial features are required to dissipate/dampen wave energy (ASCE 1969) and sustain an acceptable climate in the marina for berthed boats. Prior to marina development, it is therefore important to assess the impact of wave exposure conditions, then design the optimum orientation. Existing marinas that are exposed to unacceptable vessel-generated wave conditions must investigate the possibility of incorporating wave attenuating structures to reduce undesirable conditions in the

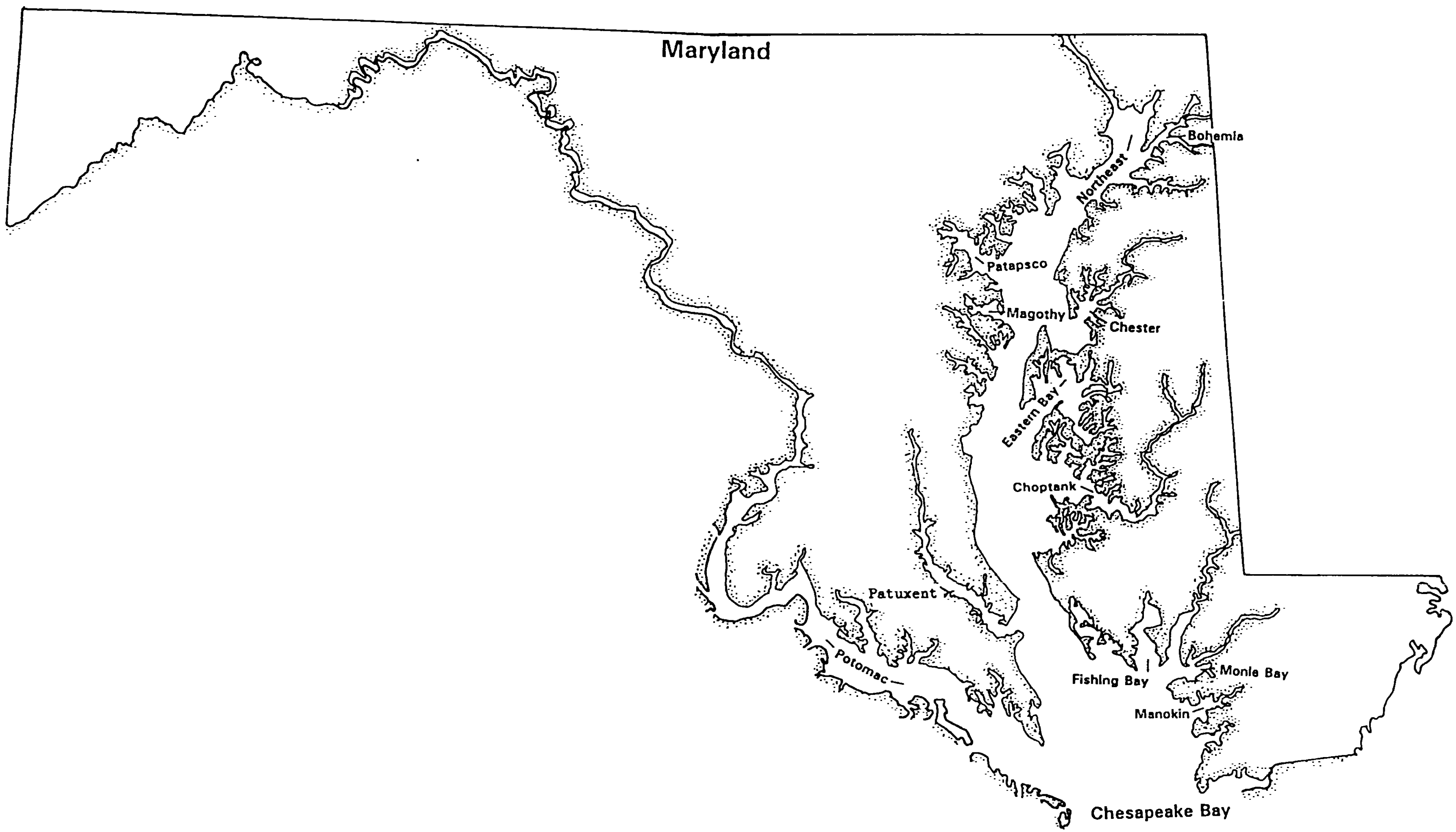


Figure 1. Water resources throughout the State of Maryland.

berthing areas. Types of alternatives available for protection against waves are discussed in Chapter 3.

To properly determine the optimum location of perimeter wave protective structures, designers must first determine the direction from which waves approach the marinas. Wave dissipating/attenuation structures then should be placed in a position so that they shelter the berthing areas of the marina. It may be necessary to overlap structures at the navigation entrance, thus preventing excessive energy from entering the harbor. Studies have shown that it is generally desirable to prevent wave energy from entering a harbor as opposed to attempting to dissipate the energy once inside the marina (Bottin 1992). Minimizing the entrance opening and using impermeable structures to alleviate wave transmission also will reduce wave energy in the marina. Additional structures located seaward of the entrance have been used to provide wave protection in harbors.

Vertical-wall bulkheads are highly reflective and should be avoided in marinas if possible. Waves reflected off a vertical-wall bulkhead may be of equal height as the incident incoming wave conditions. For example, a 1 ft wave may be increased to 2 ft in front of the reflective surface, considering the additive effects of the 1 ft incident wave and the 1 ft reflected wave. These waves may cause hazardous berthing conditions that can result in damage to facilities and small boats. If vertical bulkheads must be constructed, due to cost or other considerations, long parallel opposing structures should be avoided and rounded corners should be included in the design. The installation of wave absorbers in the marina may be considered in areas of high wave energy. Gentle beach slopes are the best type of wave absorber, however, the most common method of absorbing wave energy is the use of sloped rubble (rock) absorbers. Design procedures for rubble absorbers may be found in the Shore Protection Manual (1984). In addition, absorbing (perforated) quay walls and concrete wave absorbing units have been used to dissipate wave energy in small-craft harbors.

While determining the layout of protective structures for a marina, water quality inside the marina must be considered. Harbor circulation by tidal or wave-induced flow must be adequate to flush the marina. Several methods may be utilized to prevent stagnation and enhance circulation. Openings between the shore and protective structure will prevent confinement and result in flushing. In addition, openings in the structure (segmented or baffled structures) will enhance circulation. Care must be taken, however, since these openings may allow unacceptable levels of wave energy into the marina. Harbor circulation through the navigation entrance may be more effective if the entrance is in the mid-section of the protective structure. For instance, if the entrance is on one end of a marina, then the opposite end of the basin may receive negligible flushing and become stagnant.

Another consideration while planning the layout of a small-boat marina is the mooring orientation or dock arrangement. Short-period wind and vessel-generated waves approaching a small moored vessel from the bow or stern (head seas) result in significantly less vessel movement, and subsequently less damage, than waves approaching the vessel from broadside (beam seas). The Canadian Small-Craft Harbours Branch, Fisheries and Oceans, has examined the natural response and motions of various small craft moored at a marina dock, and formulated comprehensive small craft harbor design criteria (Cox 1987). Based on these data, acceptable wave heights in marinas for short-period wind and vessel-generated wave conditions (representative of conditions in tributaries of the Chesapeake Bay) are as follows, considering head versus beam seas and frequency of occurrence.

Acceptable Marina Wave Heights (ft)

Direction	Recurrence Interval		
	50 Year	Annual	Weekly
Head Seas	2.0	1.0	0.5
Beam Seas	0.75	0.5	0.25

As shown, the acceptable wave height criteria for vessels experiencing head seas is at least twice those experiencing beam seas. Therefore, to minimize facility and vessel damages, dock arrangements in marinas should be oriented with waves approaching vessel bows or sterns as opposed to waves approaching from broadside.

Chapter Two

VESSEL-GENERATED WAVES

GENERAL

A critical design element for a marina is determination of expected wave activity at the site. In addition to wind generated waves, a very important site consideration in rivers and tributaries is the problem of the arrival of ship and boat wakes. The effect of boat wakes on marina activities is escalating as the population of boaters grows and more marinas are being located in closer proximity to each other, resulting in the passage of many vessels past a marina. Increased usage of waterways is a fact, and wake production can only be expected to increase in the future. The design of various waterway features requires a knowledge of wave characteristics generated by vessel traffic using the waterway.

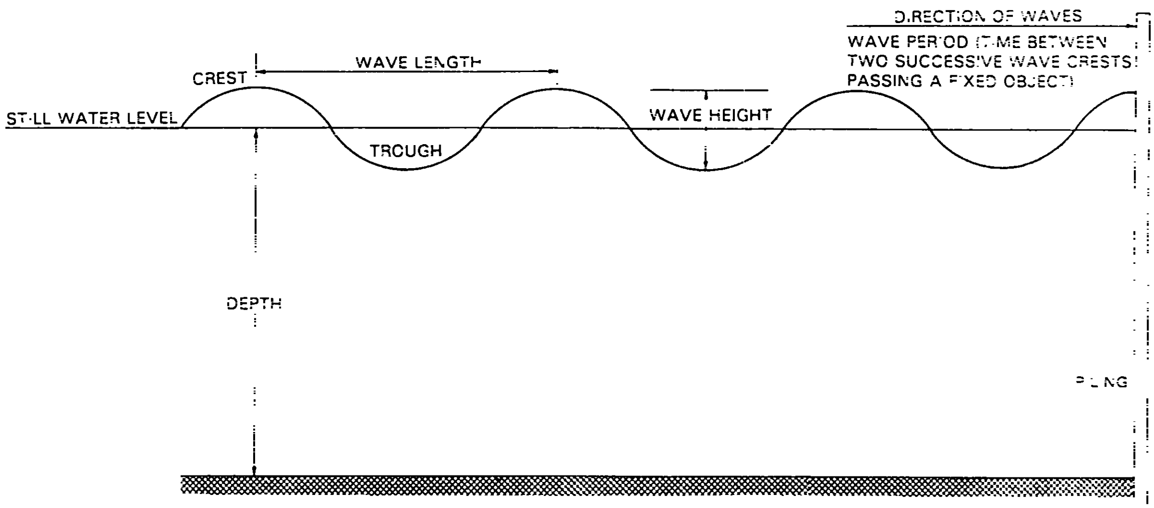


Figure 2. Common wave characteristics.

Before discussing the generation of waves produced by vessels, wave characteristics, in general, need to be understood. Whether generated by wind or vessels, waves have common characteristics as shown in Figure 2. Definitions of some of these characteristics are shown below.

- Wave Height - is the vertical distance between the crest and trough of the wave.

- Wave Period - is the length of time it takes for two successive wave crests to pass a fixed object.

- Wave Length - is the horizontal distance between two successive wave crests, and is dependent upon the period of the wave and the water depth. The longer the wave period, the longer the wave length. As a general rule, wave length can be determined as being 5.12 times the wave period squared, in deep water. For instance, a wave with a 3 sec period would have a wave length of about 46 ft (i.e., $5.12\ (3)^2$ or $5.12 \times 9 = 46.08$).

- Wave Direction - is the direction from which waves approach.

A wave visible on the water surface also exists below the surface, and generally has the same characteristics. Water movement below a passing wave crest has a circular (elliptical) path and moves in the same direction as the wave on the surface. Motions below the water surface extend to a depth of about one half the wave length. When the depth is less than one half the wave length, the wave feels the bottom and begins dragging along the bottom. As the water depth decreases, waves slow down and increase in height and their wave lengths will become shorter, (i.e. the wave crests get closer to each other). Wave direction also changes as waves approach shallow water. This phenomena is referred to as wave refraction. Wave fronts generally tend to orient themselves parallel to the underwater contours. Wave characteristics must be understood in order to develop alternatives that will minimize their undesirable effects in marinas. The important point to remember is that waves do exist at depth and are not just a surface phenomenon. This is true of not only wind generated waves, but of vessel-generated waves as well. Detailed information on the mechanics of wave motion can be found in the Shore Protection Manual (1984).

Recreational craft are very common in rivers and tributaries within the State of Maryland. Small power boats of 20 ft or less, frequently operate at high speeds, but are not capable of producing large waves particularly when they are in a plane (rising out of the water). Larger recreational power boats that are not in a planing mode, however, may generate significant wakes when traveling at speeds of around 10 to 12 knots. These wakes can be hazardous for other transient craft in the area as well as a problem for vessels berthed in nearby marinas. The actual wave height produced depends on the hull design, with the more blunt, bathtub hull shapes producing some of the largest wakes.

GENERATION OF VESSEL WAKES

Moving vessels disturb the surrounding water and generate surface waves that propagate away from the vessel. The propeller of a power boat generates a water jet of relatively high velocity that flows in the aft direction of the hull forming transverse waves. Water displacement by the vessel hull as it moves forward also generates diverging wake waves which move away from both sides of the vessel. Figure 3 shows the resulting pattern of wave crests generated by the bow of a vessel moving in deep water. The pattern consists of symmetrical sets of diverging waves that move obliquely out from the sailing line and a single set of transverse waves that move in the direction of the sailing line (Sorenson 1986). The transverse and diverging waves meet to form cusps along angles of about 19.5° out from the sailing line. The highest waves in this pattern are found at the cusp points. If the vessel speed is increased (still under deepwater wave conditions) the transverse and diverging wavelengths increase and the crest pattern expands but retains the same geometric shape.

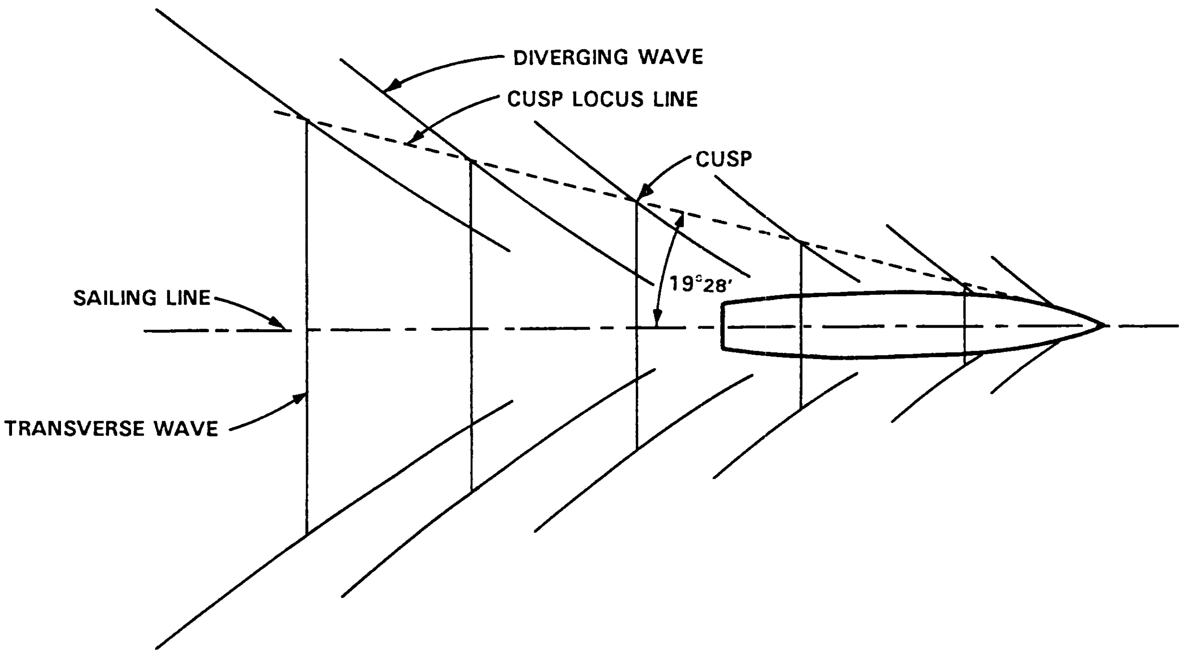


Figure 3. Typical wave patterns generated by a vessel moving in deep water.

For a vessel traveling at or below its hull speed, the wake generated by the combination of its bow waves and stern or transverse waves travels away to the left and right of the vessel's heading or course at an angle of approximately 35 degrees. Hull speed is a function of the vessel's geometry and load distribution. An approximate value of the hull speed of a vessel, not planing through the water, can be determined by taking the square root of its waterline length and multiplying it by 1.3 (Tobiasson and Kollmeyer 1991). As an example of this general rule, a 40 ft boat has a hull speed of approximately 8.2 knots (i.e., $\sqrt{40}$ (1.3) or 6.32 (1.3) = 8.22).

When the vessel moves faster than its hull speed, it begins approaching what is called its critical speed. The 35 degree wake angle relative to the craft's course begins decreasing toward 0 degrees and the wake wave period and wave length increase. The wake wave at the

the vessel's critical speed travels parallel to the boat's course and is the largest wake wave the vessel can produce. All small craft attempting to reach a planing mode of travel will momentarily go through this critical speed and produce their maximum wake.

Once a planing mode is reached, the angle of the wake wave relative to the course rapidly increases from 0 toward 80 degrees and tends to travel almost perpendicular to the hull. The height of the wake also drops dramatically and the stern or transverse portion of the hull wave disappears. Figure 4 depicts boat wake diagrams for a vessel's hull and critical speed and for a planing vessel. When planing begins, there is usually no significant increase in generated wave heights as the vessel speed increases. The reverse process occurs as the boat slows and comes off its plane. Many operators of fast moving planing boats producing a relatively small wake, mistakenly slow down in an attempt to make a smaller wake while passing other boats or shore facilities.

Waves produced adjacent to the boat's hull are in their highest form. These waves are reduced to one half this height at a distance of approximately one wave length from the hull (Tobiasson and Kollmeyer 1991). Their heights then are reduced slightly for every wave length of travel, but the number of waves in each train increases, so that as wake waves travel away from the vessel, they become lower in height but more numerous. These represent the spreading of wave energy over the surface of the water, rather than the dying out of a wake wave as may be expected.

The greater the wake's period, the farther it may travel with significant wave height. The wake wave periods remain unchanged as they travel, however, as the water depth decreases, their wave lengths will shorten. Regardless of the distance from the vessel, the series of waves generated by a vessel passing a fixed point has a single maximum wave height, (H_{max}), as shown in Figure 5. The maximum wave height and its accompanying wave period (T), are the values used in design of protective structures.

Obviously, the further the marina is from the passing vessel, or the slower the speed of the vessel (provided it is not in a plane) the smaller the waves at the marina. Unfortunately, even reduced-in-height wakes with periods on the order of about 3 seconds may produce annoying rolling and pitching conditions for docked boats. This is because most recreational craft are sensitive to periods in this range and motion is easily induced.

PREDICTED WAVES FOR VARIOUS CRAFT

To predict the wave climate (wave height, period, direction of approach) that may be expected at a marina site due to vessel-generated waves, the boat's speed and direction, the water depth, the boat's hull form and draft, and the distance from the marina must be known. This portion of the guidebook presents graphs which enable the prediction of approximate wave heights, periods, and directions for selected vessel types and operating conditions.

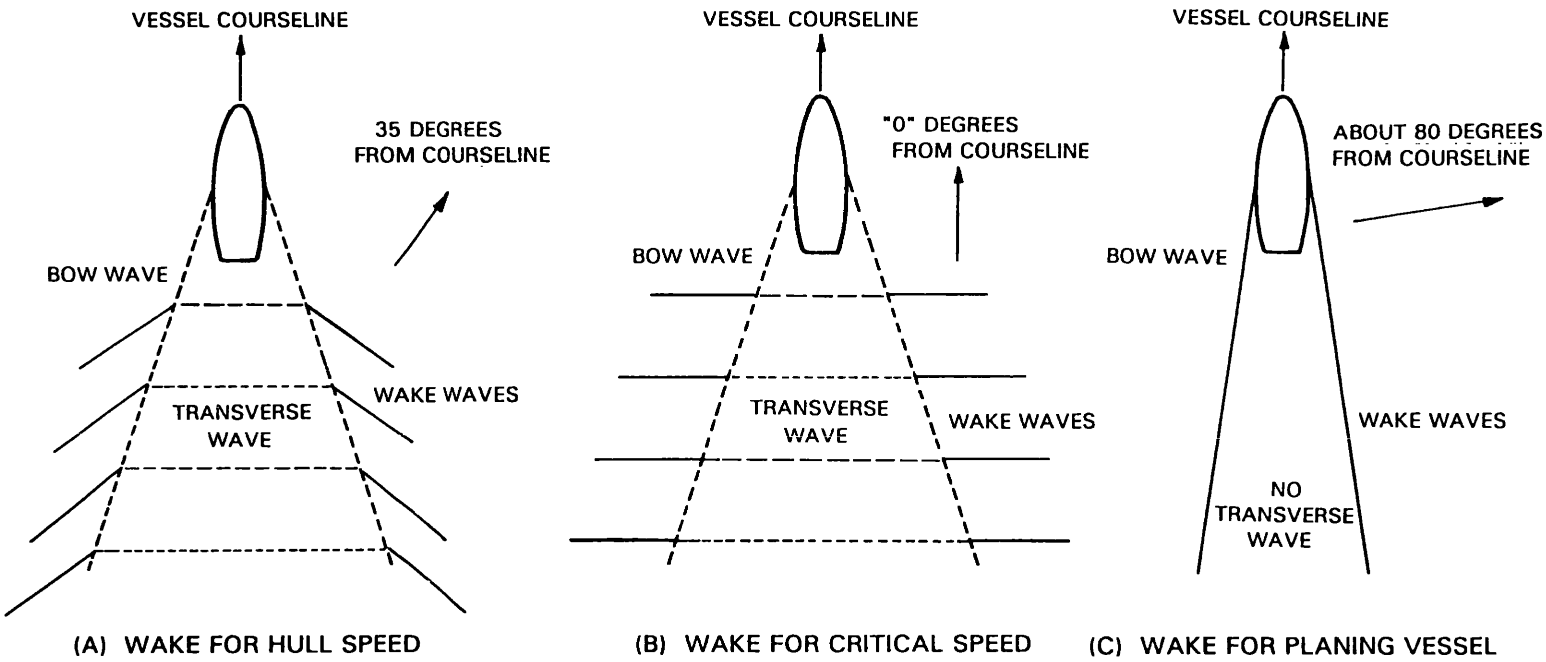


Figure 4. Boat wake diagrams for a vessel traveling at (a) hull speed, (b) critical speed and (c) planing vessel.

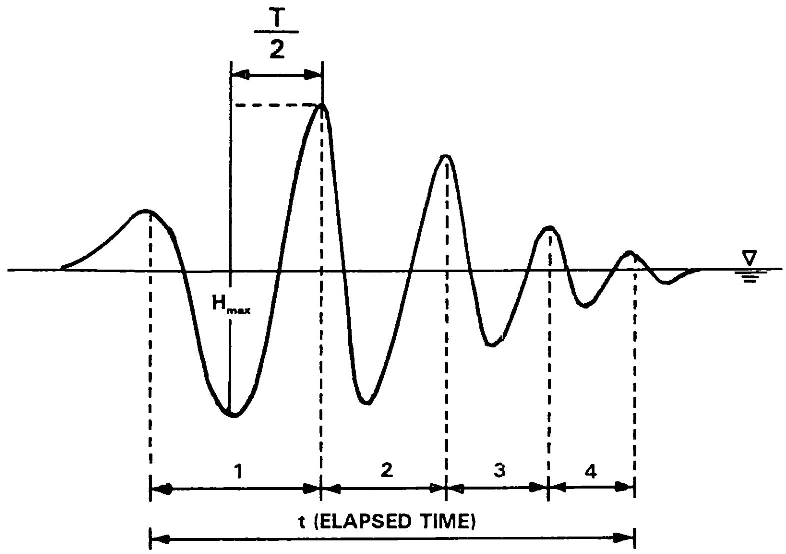


Figure 5. Typical time series for vessel generated waves passing a fixed point.

Vessel types are limited to recreational vessels, ranging from 14 to 52 ft in length. Operating conditions consist of: vessel speeds of 5, 8, 10, and 12 knots; water depths of 8, 15, and 25 ft; and distances ranging from 25 to 1500 ft from the vessel courseline to the marina.

To predict wave characteristics for various vessels, it is necessary to first calculate the vessel Froude number (F). The Froude number is a dimensionless ratio of the inertial force to the force of gravity for a given vessel velocity. The vessel Froude number may be calculated using the following equation.

$$F = \frac{v}{\sqrt{gd}}$$

In the equation, the speed of the boat (v), the acceleration due to gravity (g), and the water depth (d) are used to determine the vessel Froude number. As the Froude number increases from 0.7 to 1.0, several changes occur (Sorenson 1986). This represents a vessel moving from its hull speed to its critical speed, as discussed earlier. Wave heights and periods increase at a faster rate and the 35 degree wake angle relative to the craft's course decreases from 35 to 0 degrees. A vessel Froude number of 1.0 occurs at the vessel's critical speed.

Wave period prediction. For a given vessel speed and water depth, the value of the wave period can be predicted after the vessel Froude number is calculated. The period of a vessel generated wave is a function of vessel speed and water depth only and does not depend on the size or the hull type of the vessel. The influence of the vessel speed and water depth are contained in the vessel Froude number. Wave period versus Froude numbers are shown in Figure 6 for 8, 15, and 25 ft depths. Wave periods for additional water depths can be determined by interpolating between the values presented for the three water depths shown.

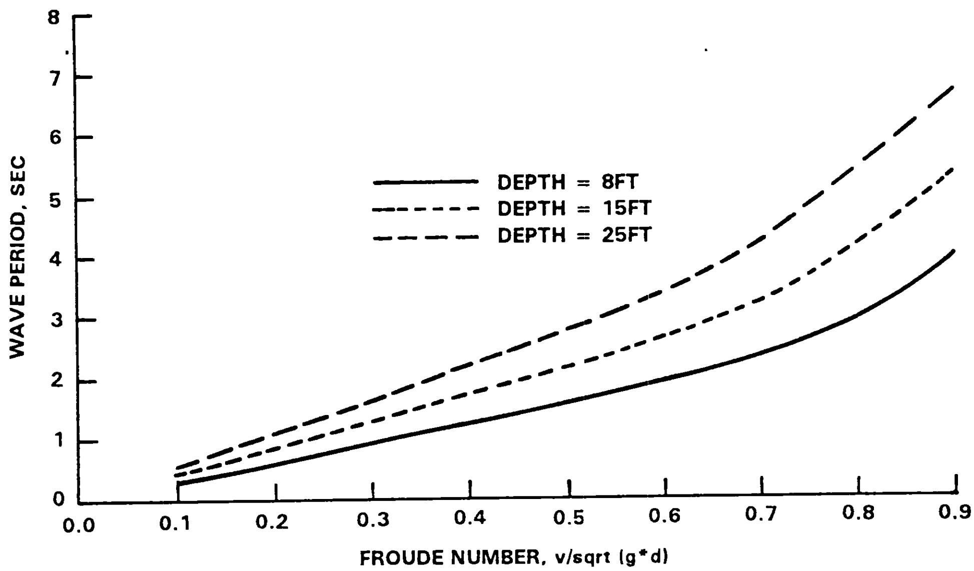


Figure 6. Wave period for vessel-generated waves versus Froude number.

Wave direction prediction. For a given vessel speed and water depth, the value of the wave angle (relative to the vessel's courseline) can be predicted after the vessel Froude number is calculated. As is the case for wave period, the wave direction is only a function of vessel speed and water depth. Wave angle versus Froude numbers are presented in Figure 7. Note the wave angle change when the Froude number is 1.0, the vessel's critical speed.

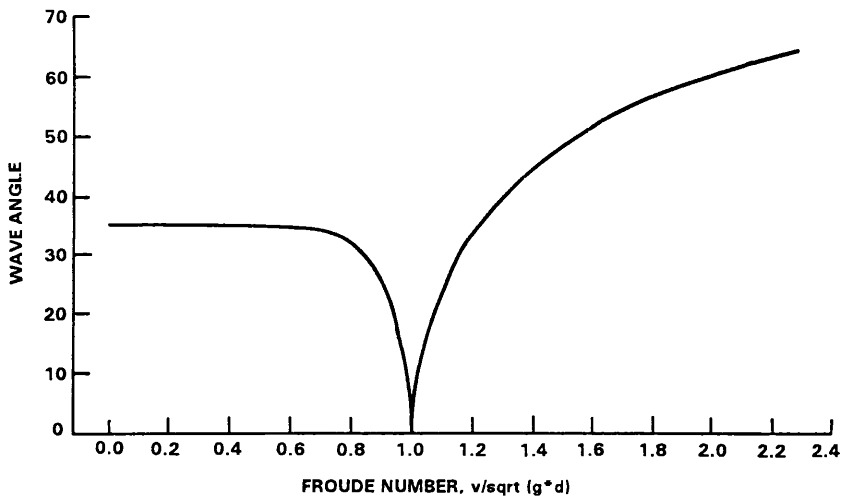


Figure 7. Angle of wave propagation (relative to vessel courseline) versus Froude number.

Wave height prediction. Wave heights generated by recreational-type vessels are not only dependent on vessel speed and water depth, but are also a function of the vessel's geometric characteristics as well as the distance from the courseline. Wave generating characteristics depend on the vessel's size (length, beam, draft, and displacement) and hull form. Currently, all of these variables can not be factored into a predictive model, and the equations used to predict wave heights generated are mainly dependent on the size of the vessel and not the hull configuration. The actual wave height produced depends on the shape of the hull, with the more blunt hull shapes producing the largest waves. The wave generating characteristics for a whaler with a three-point planing hull are quite different than a cabin cruiser with a v-shaped hull. Therefore, wave heights provided in this report should not be taken to be exactly the wave that would be produced, but more as an aid in determining the magnitude of wave conditions which may occur at a marina for a range of vessels and operating conditions.

Eight vessels were selected to represent the range of recreational vessels utilizing the tributaries of the Chesapeake Bay. The vessels range in length from about 14 to 52 ft and have displacements ranging from 750 to 51,000 lbs, as shown in the following table.

Vessel Description	Length (ft)	Beam (ft)	Draft (ft)	Displacement (lbs)
Whaler	13.5	6.0	0.5	750
Maxum	19.8	7.8	2.8	2,480
Penn	26.2	8.5	2.8	4,600
Chapparal	28.4	9.0	2.8	6,320
Silverton	34.7	12.9	2.9	19,000
Dawson	38.0	13.7	3.5	30,000
Hatteras	46.8	15.6	4.7	51,000
Jefferson	52.3	16.0	4.0	48,500

When selecting a vessel which closely represents the "typical" vessel operating in a given area, the major emphasis should be placed on the displacement of the vessel, since this is the main parameter used in the equation to predict wave height.

Given the type of vessel expected to use an adjacent waterway along with the operating speed, water depth, and distance from the vessel's courseline to the marina, an estimated wave height can be determined using an empirical equation. A series of graphs to aid in the prediction of wave heights expected at a marina is presented in Appendix A for the eight recreational vessels shown above. The selection of the graph to be used depends on the vessel type and the water depth. From the graphs, estimated maximum wave heights may be determined at varying distances from the sailing line (vessel courseline) for different vessel speeds.

Example problem. A marina is located approximately 100 ft from a channel. Vessels, 46-ft in length with a displacement of 51,000 lbs, typically travel past the marina at a speed of 10 knots. The water depth is about 25 ft. What is the approximate wave period, wave direction, and wave height expected at the marina based on these occurrences?

To determine wave period and angle of wave propagation, the vessel Froude number first must be calculated

$$F = \frac{v}{\sqrt{gd}} = \frac{10 \text{ knots} \times \dfrac{1.688 \text{ ft/sec}}{1 \text{ knot}}}{\sqrt{32.2 \text{ ft/sec}^2 \times 25 \text{ ft}}} = 0.60$$

where 1.688 is the conversion from knots to feet per second and 32.2 ft/sec^2 is acceleration due to gravity. The calculation results in a vessel Froude number of 0.6. Using Figure 6, with a 25 ft depth, a wave period of about 3.4 seconds is estimated. Also, using the 0.6 Froude number with Figure 7, an angle of wave propagation of 35 degrees relative to the vessel's courseline is predicted. Note that the angle of wave approach at the marina depends on the orientation of the channel to the marina. To determine the estimated wave height, given the dimensions of the vessel and the 25 ft depth, the appropriate graph is selected from Appendix A. Using the graph on page A22, with a distance of 100 ft from the sailing line and a speed of 10 knots, a maximum wave height of about 1.5 ft is estimated at the marina.

Chapter Three

TYPES OF ALTERNATIVES AVAILABLE FOR PROTECTION AGAINST VESSEL-GENERATED WAVES

RUBBLE-MOUND BARRIERS

Most breakwaters built on the open coasts and large bodies of water in the United States to protect harbors from wave action, are generally of rubble-mound construction. Rubble-mound structures typically are constructed with a core of quarry-run stone, one or more underlayers, and a cover layer composed of larger stone or possibly a manufactured concrete armor unit. These structures are suitable for nearly all types of foundations and any economically acceptable water depth.

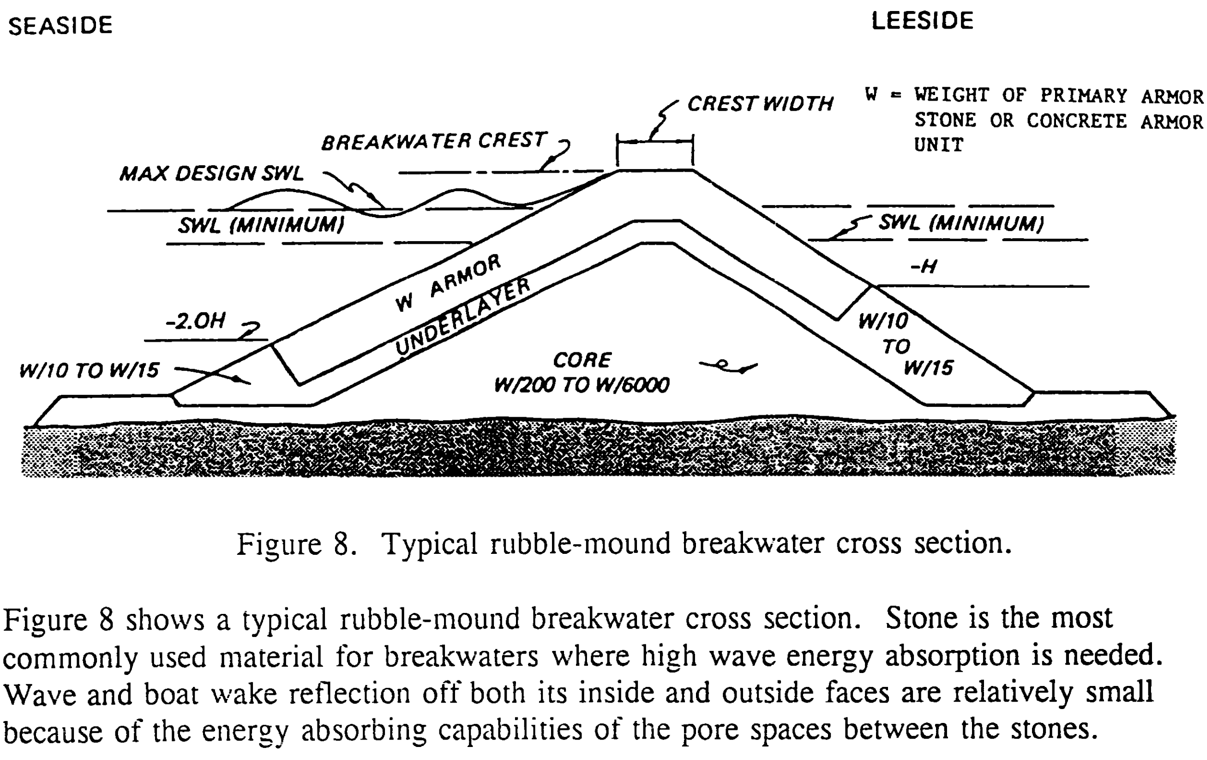


Figure 8. Typical rubble-mound breakwater cross section.

Figure 8 shows a typical rubble-mound breakwater cross section. Stone is the most commonly used material for breakwaters where high wave energy absorption is needed. Wave and boat wake reflection off both its inside and outside faces are relatively small because of the energy absorbing capabilities of the pore spaces between the stones.

Rubble-mound wave barriers can be designed to be either permeable or relatively impermeable to oncoming waves. Stone sizes used depend on site conditions and hydraulic considerations at the harbor site. Design procedures may be obtained from the Shore Protection Manual (1984). Upon settlement or damage due to extreme waves, rubble-mound breakwaters may be easily repaired by installing additional stone.

Disadvantages of rubble-mound structures include the large quantity of material required and high initial material costs. The shape of a rubble-mound structure includes a broad base and a narrow top, or crest. The deeper the water, the wider the base will be, therefore, requiring increased stone volumes. These structures require larger volumes of materials than most other types of breakwaters. If adequate quantities of the required stone are not available, costs of transportation and handling could be significant as well as the costs of the stones themselves. A typical rubble-mound breakwater is shown in Figure 9.

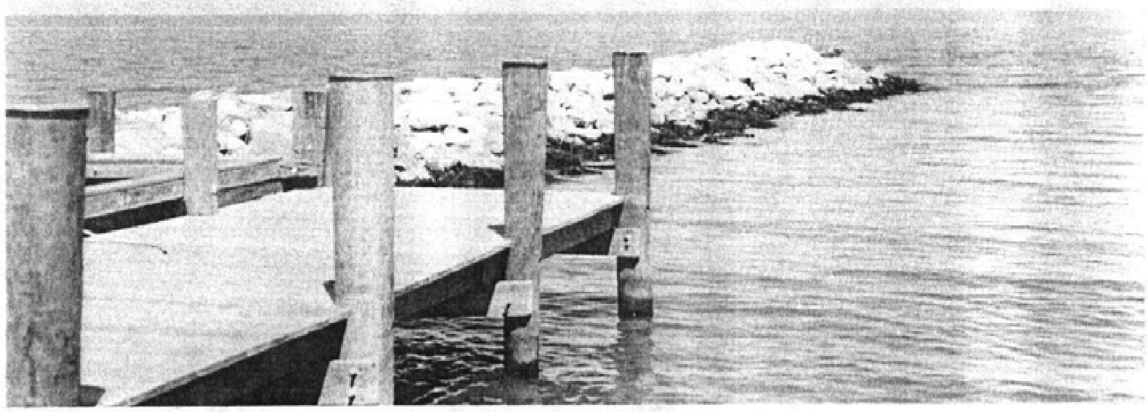


Figure 9. View of a rubble-mound breakwater.

SOLID VERTICAL WAVE BARRIERS

Solid vertical type breakwaters are used where less severe wave exposure occurs, relative to the open ocean coasts. Interlocking sheet-pile walls and sheet-pile cells of various shapes are in common use as well as stone-filled cribs, concrete caissons, monolithic walls, closely spread metal cylindrical piles, and in some cases, wood pile and timber barriers. For more severe wave exposure, cellular-steel sheet-piles, cribs, caissons, and monolithic walls are used. These structures are generally stone filled. A cellular steel sheet-pile breakwater is shown in Figure 10. Single vertical sheet pile walls (steel, concrete or timber) are generally

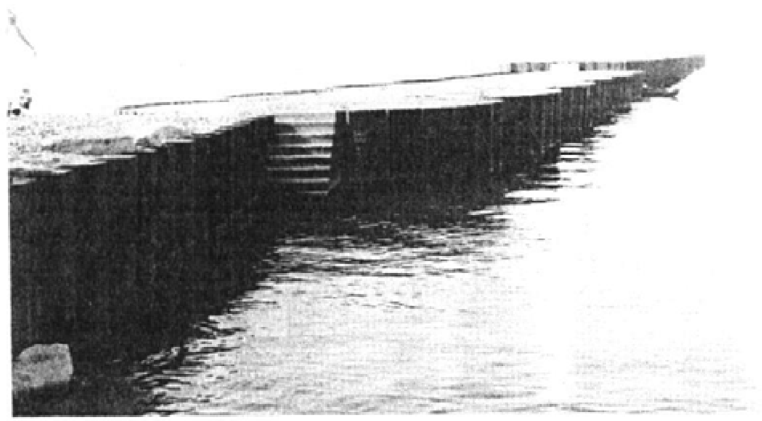


Figure 10. View of cellular sheet-pile breakwater.

used in relatively shallow depths where storm waves are mild. Considerable bracing or batten pile support may be required if these structures are subjected to extreme waves. An example of a timber sheet-pile breakwater plan is shown in Figure 11. Solid vertical barriers are impermeable to wave transmission and result in very calm conditions on the harbor or marina side of the structure.

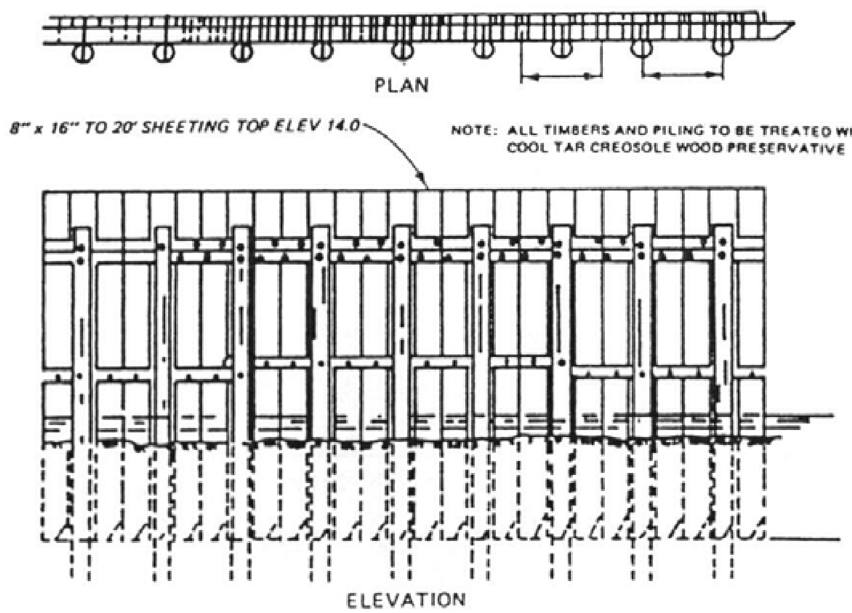


Figure 11. Example of timber sheet pile breakwater.

The major disadvantage to solid structures is that they are highly reflective. Waves reflected from these structures may cause hazardous entrance conditions as well as reflected energy in mooring areas. In addition, the foundation toe areas of vertical structures are subject to scour (erosion) due to wave and current action. Wave turbulence sets sediments into suspension and currents carry them away. Stone riprap at the base of the barrier is often used as a scour inhibitor.

WAVE BOARDS AND WAVE FENCES

Wave boards and wave fences are horizontally or vertically erected planks, which are attached to support wales, with a pre-determined spacing between the planks. The spaces between the planks allow for water circulation and reduced forces. The function of these structures is to intercept some wave energy and allow some to enter the marina area. A view of a wave fence is shown in Figure 12. Wave board spacing is critical. Energy entering the marina is dependent on the proportion of the space between the boards and on the width of the boards. The spacing of the wave boards and the distances between the boards and the bottom allows for water circulation into and through the marina, which provides flushing by wave-induced, tidal, and/or river currents. Other considerations involving methods to enhance marina circulation were mentioned in Chapter 1.

Figure 12. View of a wave fence.

Two considerations must be addressed to predict the functioning of wave board arrays. The first includes the board width and spacing to be used, and the second includes the draft of these boards, or how deep in the water column they are to be set. Depending on the wave period, significant wave energy can pass below the boards at different distances from the bottom. The longer the period, the greater the energy that passes below the wave boards, if they do not extend to the bottom. Unfortunately, at marina sites, wave boards are in shallow water and must extend to the bottom to be effective. The only difference from a solid barrier is the board spacing.

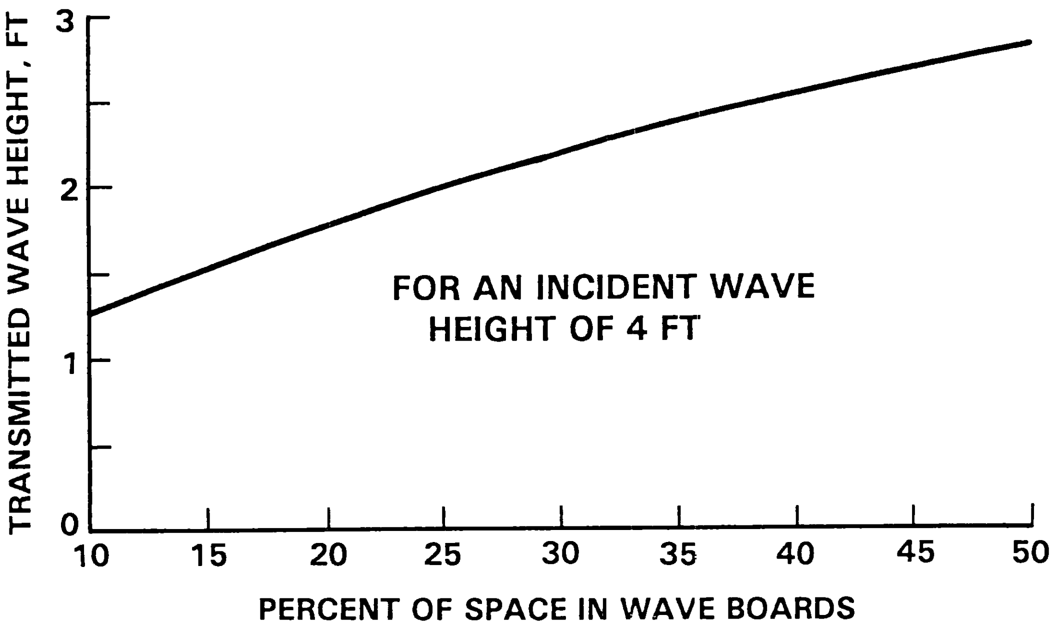


Figure 13. Wave board effectiveness (transmitted wave height vs. percent of space in wave boards).

Spacing between boards also may allow significant energy to pass through. Figure 13 (Tobiasson and Kollmeyer 1991) shows wave board effectiveness for 4-sec, 4-ft high waves. It plots the variation in the percent of board spacing allowed versus transmitted wave height. The wave boards are assumed to extend to the bottom and no energy can pass underneath to add to the transmitted wave height. As shown, the initial 4 ft wave is reduced to 3 ft (25 percent reduction) with 50 percent board spacing, to 2 ft (50 percent reduction) with 25 percent spacing, and to 1.3 ft (67 percent reduction) with 10 percent spacing. As demonstrated, the effectiveness of these devices is dependent on the spacing. It is obvious that increasing gaps between the boards to save money is not cost effective considering wave attenuation.

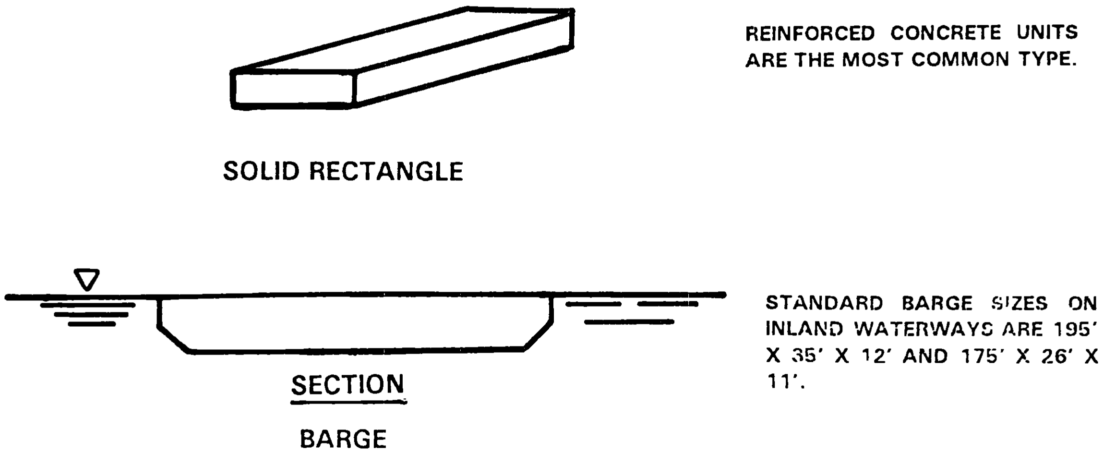
The depth or draft of the wave boards, or how close to the bottom they extend is another important consideration. If they do not extend to the bottom, the wave energy that passes underneath the boards will result in an additive effect to the wave heights transmitted through the board spacings. Energy passing underneath the wave boards will vary with the period of the incoming waves . The energies of longer period waves are more uniformly distributed in the water column. Any space between the ends of the wave boards and the bottom allows energy to pass underneath and reform waves on the marina side, adding to those wave heights passed through the board spacings themselves. The reformed waves have heights only a little less than the incident wave itself. An example, using 4-sec, 4-ft waves and 15 ft water depths, shows the wave heights that will be transmitted below the board drafts given (Tobiasson and Kollmeyer, 1991).

Board Draft	Water Space Below, ft	Incident Wave Height	Transmitted Wave Height
9	6	4.0	1.9
12	3	4.0	1.4
15	0	4.0	0.0

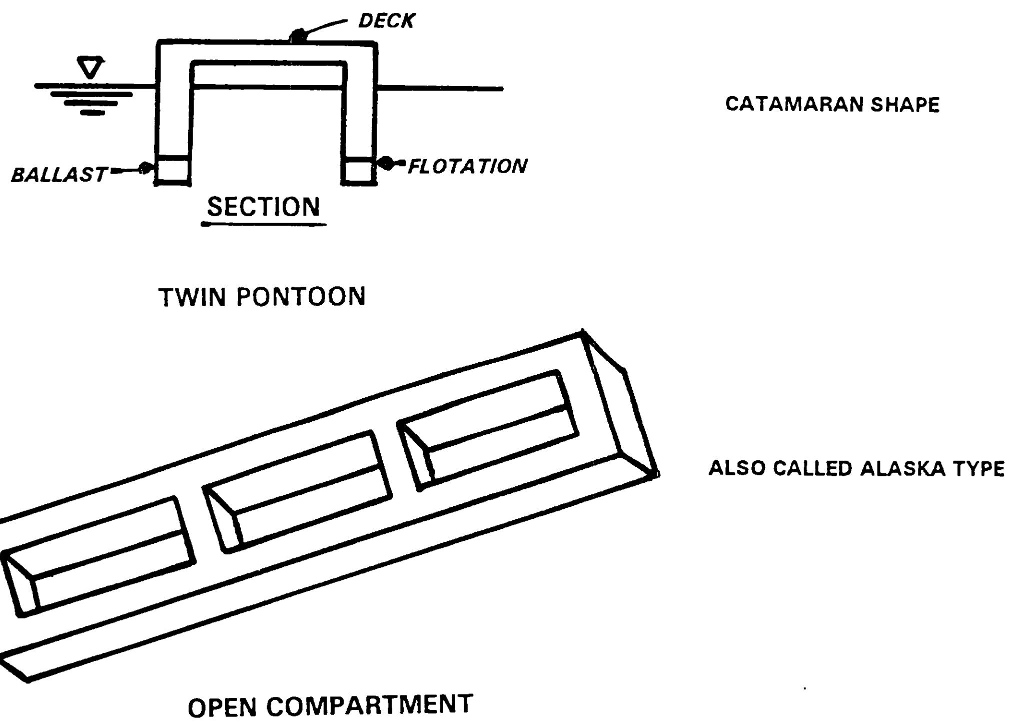
As shown, board drafts extending to the bottom allow no transmitted wave, however, 12 ft drafts (20 percent opening at bottom) result in a 1.4 ft (65 percent reduction) transmitted wave height, and 9 ft drafts (40 percent opening at bottom) allows a 1.9 ft (53 percent reduction) transmitted wave height. It is important to remember that when energy passes under the wave boards, the resulting wave heights must be combined with those wave heights that may pass though the wave board spaces. Wave boards are frequently seen attached to the outside of a fixed dock and not extending to the bottom. These installations not only allow wave energy to pass through the board spacings, but energy passes beneath them as well. Many marina operators are puzzled and disappointed by the wave activity in their marinas after the installation of these wave boards.

FLOATING WAVE ATTENUATORS

Any structure which has a composite unit weight less than the water in which it is placed and is primarily used to reduce wave heights can be categorized as a floating breakwater. These attenuators can provide a degree of marina protection for wind waves with relatively short wave periods and boat wakes. These structures are available in a variety of sizes, designs, and materials. They can be box, pontoon, scrap-tire, A-frame, mat, tethered float, or a variety of other types. At least 60 different floating breakwater configurations are recognized, however, the most commonly used types are shown in Figure 14. Floating breakwaters provide less wave protection than bottom fixed structures, but they are less expensive and are movable from one location to another as required. Water depth has little influence on in-place costs or breakwater performance. Floating structures may be used where large tidal fluctuations or fluctuating reservoir pool elevations are encountered since the mooring line system can be adjusted to keep the breakwater in its optimum performance

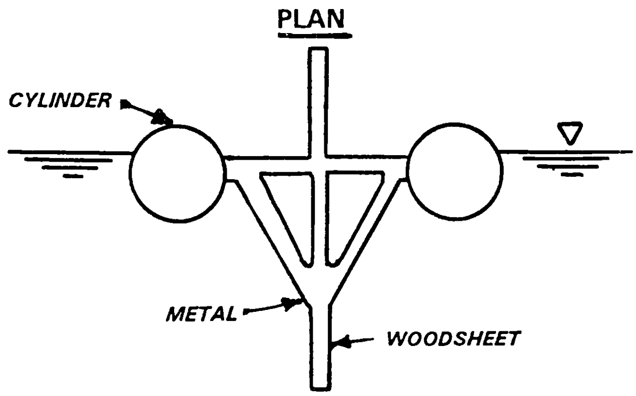


a. Box type



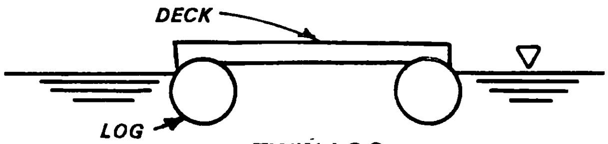
b. Pontoon type (continued)

Figure 14. Commonly used floating breakwater types (Continued).



SECTION

A FRAME



DECK IS OPEN WOOD FRAME.

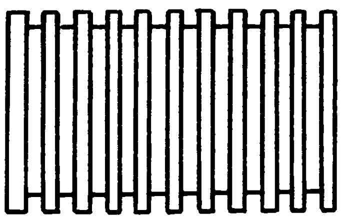
TWIN LOG

b. Pontoon type (concluded)

SECTION

TIRE MAT

SCRAP TIRES STRUNG ON POLE FRAMEWORK OR BOUND TOGETHER WITH CHAIN OR BELTING. FOAM FLOATATION IS USUALLY NEEDED.



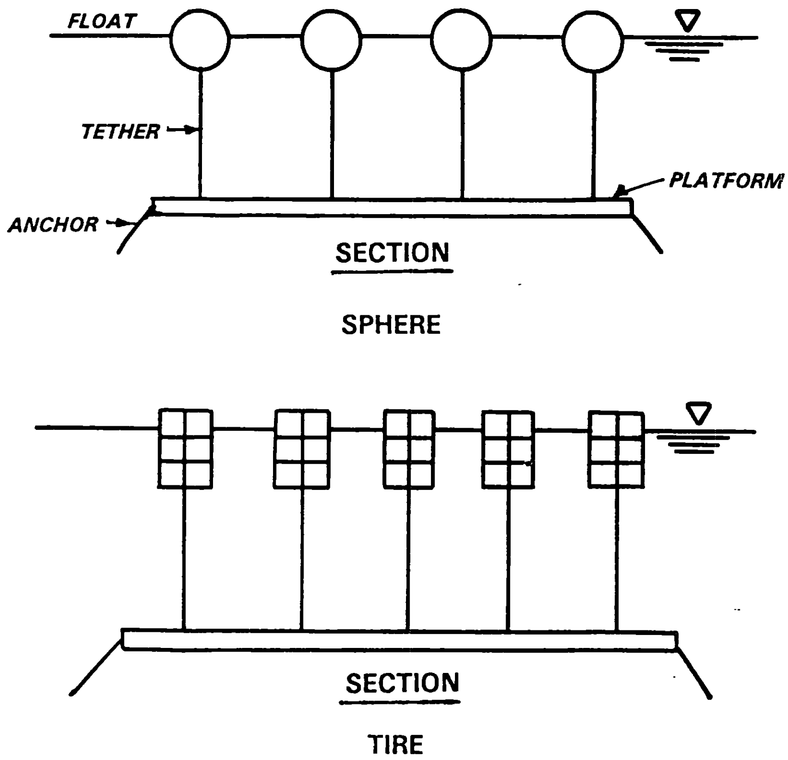
PLAN

LOG MAT

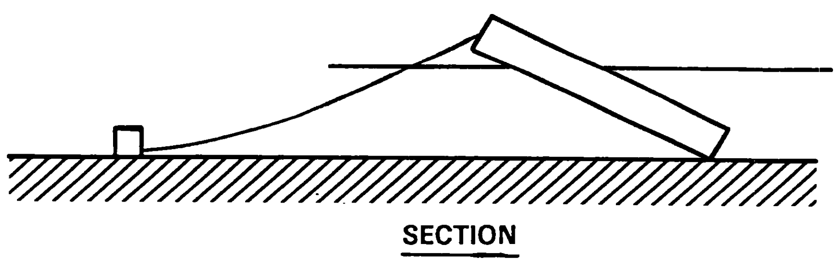
LOG RAFT CHAINED OR CABLED TOGETHER.

c. Mat

Figure 14. Commonly used floating breakwater types (Continued).



d. Tethered float



e. Sloping float

Figure 14. Commonly used floating breakwater types (Concluded).

configuration. Interference with natural water circulation is minimal with floating structures, they do not form barriers for suspended or bed load sediment transport, and they have a low profile and present a minimum intrusion on the horizon.

The effectiveness of floating breakwaters is usually dependent upon their mass, which is related to their volume and water displacement. The greater the horizontal (width) and draft (depth) dimensions, the greater their displacement and effectiveness. Fundamentally, constraining the water's surface with a large fixed-in-place object reflects the wave as it attempts to pass beneath. The longer or wider the space restrained on the water surface, the better reflection it makes resulting in a reduced wave height once the wave passes underneath it. This reflection occurs between the constrained upper surface and the bottom. Low profile floating structures also allow waves to break over them, expending the upper part of the waves' energy across their surface.

Examples of the effectiveness of floating breakwater width and draft are illustrated in Figures 15 and 16 (Tobiasson and Kollmeyer 1991). Figure 15 is derived from a theoretical analysis of a generic floating attenuator. It was assumed that the attenuator was a surface constraint on the water with no draft and that it was fixed in place and of sufficient mass to prevent movement in either the vertical and horizontal directions. For this condition, attenuators of 12, 18, and 24 ft in width were evaluated for waves arriving at 90 degrees to the structure axis in an 18 ft water depth. It can be seen that the transmitted wave height is reduced as the width of the attenuator increases. The performance of floating structures is also directly related to the wave periods in which they are exposed. Performance is rapidly reduced as the wave period increases to 4 seconds and beyond. As shown, a 24-ft-wide attenuator will reduce an incoming 2-sec wave by 75 percent, but will only reduce a 5-sec wave by 20 percent. Figure 16 depicts the theoretical effects of a constrained barrier with 2, 4, and 6 ft drafts, but without any width. For the same 90 degree wave angle in 18 ft of water, the deeper drafts result in less wave transmission. Improvement in attenuation is considerable for the shorter, 1 to 3 second waves as the draft is increased, while improvement is less dramatic for 4 to 8 second waves. With a 6 ft draft, a 3 second wave is reduced by 58 percent of its original height, while an 8 second wave is attenuated by only 20 percent. These examples involve waves approaching from 90 degrees. With regard to floating attenuator widths, the greater the angle, or the more oblique the waves arrive relative to the structure, the greater will be the wave attenuation. Therefore, if a floating device is being considered at a particular site, it should be oriented to receive predominant waves at the most oblique angle possible. No attenuation improvement can be expected from oblique wave angles when considering the draft of a floating structure, however.

In summary, the performance of floating attenuators is directly related to the wave periods in which they are exposed. The longer the wave period, the less effective the wave attenuation. When the effects of width and depth are combined, the attenuation results are significantly increased. A floating attenuator that moves up and down or back and forth has a significantly reduced attenuation ability, regardless of its width and draft. For many sites, floating wave attenuators may be the best solution for providing protection from small short-period wind waves and boat wakes while providing the least impact to the environment.

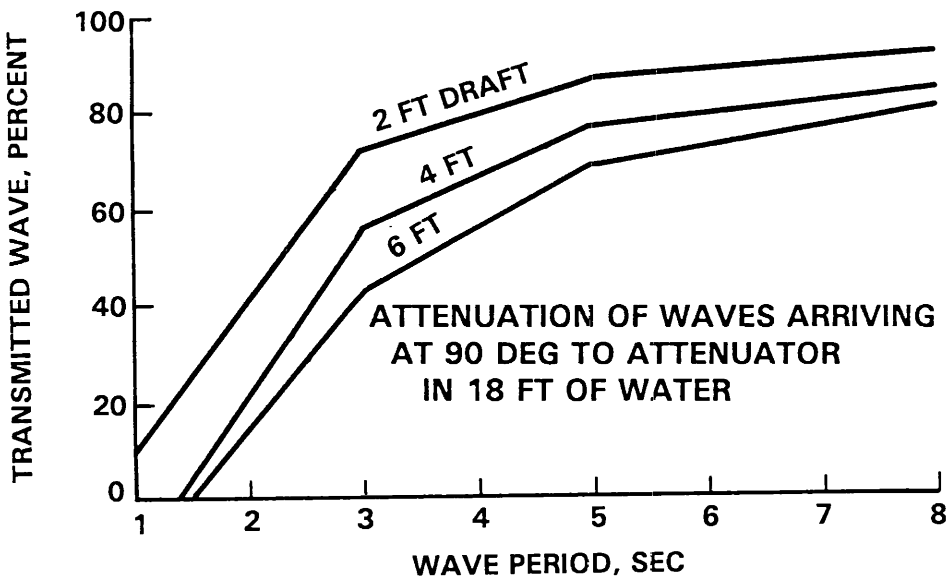


Figure 15. Floating breakwater effectiveness for various widths.

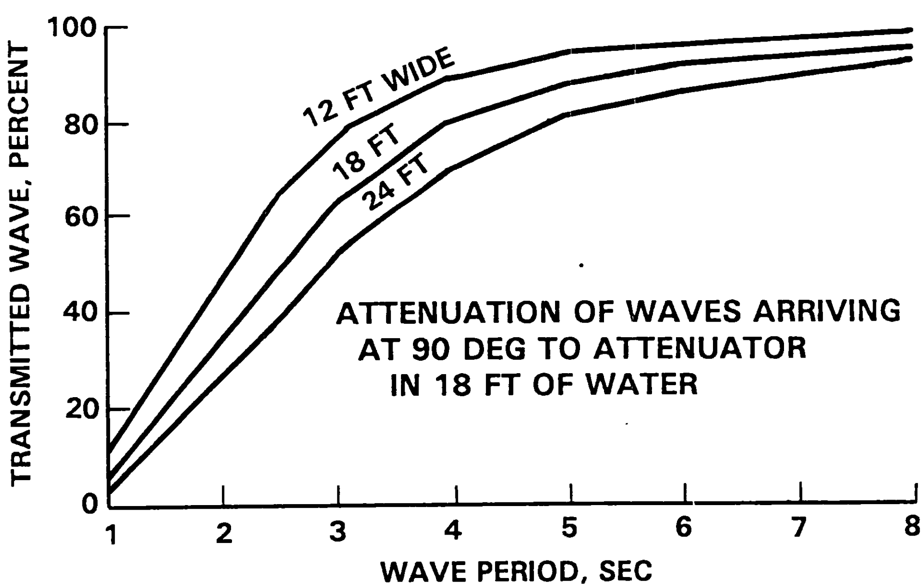


Figure 16. Floating breakwater effectiveness for various drafts.

CHAPTER FOUR

RELATIVE COMPARISONS OF ALTERNATIVE COSTS AND EFFECTIVENESS

This chapter presents information regarding costs and effectiveness of various types of alternatives available for the protection of marinas against vessel-generated waves in the Chesapeake Bay tributaries. The effectiveness of the various alternatives are addressed as well as relative costs. Costs are relative to each alternative structure type and expressed as high, medium, or low. More detailed information about each structure type can be found in Chapter 3. This chapter summarizes the effectiveness of various structures.

Probably the most effective structures for protection of marinas against waves (either wind or vessel-generated waves) is the rubblemound breakwater. The barrier may be designed relatively impermeable, to prevent excessive transmitted wave energy from entering the harbor. In addition, the sloped stone structure minimizes wave reflection and absorbs wave energy. The cost of a rubblemound structure, however, is relatively high due to the quantity of material required, particularly in deeper water.

Solid vertical breakwaters (such as stone-filled steel sheet-pile walls or cells, concrete caissons and monolithic walls) are impermeable and result in very calm conditions on the marina side of the barrier. Relative costs of these structures are high. On the other hand, single vertical sheet pile walls (steel, concrete, or timber) may be successfully used in relatively shallow water depths for protection against vessel-generated waves. Relative costs for these structures are medium. All vertical wall structures are highly reflective and should be oriented so as not to reflect wave energy into mooring or berthing areas.

Floating breakwaters may be effective in providing protection from boat wakes, however, they provide less protection than bottom-fixed structures. As discussed in Chapter Three, their performance is related to the wave periods in which they are exposed. Additional width and depth of the structures significantly increase attenuation, and these breakwaters have minimum impacts on the environment. Relative costs for floating breakwaters are low.

Wave boards and wave fences may provide adequate protection from vessel-generated waves, provided the spacing between the boards and the distance between the boards and the bottom of the water are minimal. As shown in Chapter Three, only small spacings between boards and/or openings between the board and bottom will allow significant wave energy to pass through into the marina. The more solid these attenuators are constructed, the more effective they will be. Costs relative to other alternatives are medium.

The costs of protective structures are highly variable and dependent on the site. Water depths (where the structures are to be placed) and the expected wave conditions at the site are very important considerations, relative to the effectiveness and costs for the selected barrier.

CHAPTER FIVE

SOURCES OF WAVE ATTENUATION ALTERNATIVES

The tabulation provided in the chapter lists sources for various types of wave attenuating devices and/or structures. This table generally includes nationwide manufacturers and/or sales consultants for various alternatives rather than local design or construction firms. Prior to implementation of these products, an engineering firm familiar with marina design and the use of wave attenuation devices should be consulted.

Most of the sources provided in the table are for floating wave attenuators since these types of structures are typically marketed as a commercial product. Rubblemound structures, steel sheet-pile structures and/or timber structures such as wave boards or fences are not generally marketed as a product; therefore, an engineering firm should be consulted directly for the services required to design and construct these types of alternatives. A list of marine contractors and material suppliers in the State of Maryland is provided in Appendix B.

The table was compiled from information supplied courtesy of the International Marina Institute, Wickford, RI; Andrews Miller and Associates, Cambridge, MD; and Offshore and Coastal Technologies, Avondale, PA. Additional sources to be included in this list are welcomed and will be included in periodic updates of this manual.

Sources of Wave Attenuation Alternatives

Company	Services	Features
Atlantic-Meeco, Inc. 1501 East Gene Stripe Blvd. P.O. Box 518 McAlester, OK 74502 Telephone (918) 423-6833	layout, design, maintenance, permit assistance, turnkey, management	floating wave attenuators, systems fit specific sites, hanging concrete panel with float system
Bellingham Marine Industries P.O. Box 8 Bellingham, WA 98227 Telephone (206) 676-2800 (offices also in Jacksonville, FL and Dixon, CA)	layout, design, engineering, permit assistance, turnkey, general contracting	floating wave attenuators, extremely stable systems, uses concrete floats, box beam, horizontal ladder
Concrete Flotation Systems, Inc. 33 Ann St., Box 1440 South Norwalk, CT 06854 Telephone (203) 853-2311	marina systems customized to site	concrete marine floats and floating "wavebreaks", 8 or 10 ft wide and 3 ft height floats, modules are structural lightweight concrete with solid polystyrene core
Marina Ventures, Ltd. 2501 Boston St. Baltimore, MD 21224 Telephone (410) 522-4007	layout, design, permit assistance, engineered drawings, turnkey	floating wave attenuator, polyethylene pontoons filled with concrete ballast
Sullivan Flotation Systems P.O. Box 639, Kings Highway Warwick, NY 10990 Telephone (914) 986-7377 and (800) 232-3625	leasing, layout, design, turnkey, project management	floating wave attenuator, patented flotation pontoon with foam core
TECHNOMARINE/ STRUCTURMARINE, Inc. 120 Industrial Blvd. Suite 200 Repentigny, Quebec CANADA J6A 4X7 Telephone (514) 585-6114	layout, design, financing	two types of floating breakwaters available, TECHNOBOOM (aluminum alloy, foam filled polyethylene flotation units) and TECHNOSCREEN (steel, wood, and foam filled polyethylene units with vertical reflection wall)
Walcon Barnegat 23 Congress St. Salem, MA 01970 Telephone (508) 745-6094	design, custom, turnkey systems	two types of floating wave attenuators, Walibreak Raft (series of large, flat floats interconnected with chains and flexible coupling) and System 4000 (segmental fiber and galvanized steel reinforced concrete boxes with polystyrene cores
Waveguard International P.O. Box 21304 Seattle, WA Telephone (206) 728-3129	layout, design	Offset Reflecting Wall

Chapter Six

FEDERAL AND STATE REGULATORY REQUIREMENTS

This chapter presents background information on federal and state regulatory requirements, including a description of the permitting process, a sample application form, and a summary of agencies involved in the regulatory program. The information provided herein is summarized from the "Joint Permit Application for Construction in any Floodplain, Waterway or Wetland Area in Maryland," Instruction Booklet for the State of Maryland and the U.S. Army Corps of Engineers (USACE) (January 1988), and the "Announcement of Revision of Joint Permit Application" (January 1991). A formal revision and new printing of the Joint Application booklet is in progress. Until the new booklet is available, applicants can expedite the permit process by using the revised application form provided with the "Announcement of Revision of Joint Permit Application (1991)."

REGULATORY AUTHORITY OF THE FEDERAL GOVERNMENT

The USACE has been involved with regulatory activities in the nation's waterways since 1890 with the primary purpose of protecting navigation. Since 1968, the federal regulatory program has evolved into one involving the full public interest by balancing favorable impacts against detrimental impacts. This is known as the "public interest review." The regulatory program considers the nation's concerns for the protection and utilization of important resources.

Authorities of the USACE to issue permits are primarily based on the following laws:

Section 9 of the Rivers and Harbors Act of 1899 (33 U.S.C. 401) prohibits the construction of any dam or dike across any navigable water of the United States without Congressional consent and approval by the USACE and the Secretary of the Army.

Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) prohibits the obstruction or alteration of navigable waters of the United States without permit by the USACE.

Section 11 of the Rivers and Harbors Act of 1899 (33 U.S.C. 404) authorizes the Secretary of the Army to establish harbor lines channelward of which no piers, wharves, bulkheads, or other works may be extended or deposits made without approval by the Secretary of the Army.

Section 13 of the Rivers and Harbors Act of 1899 (33 U.S.C. 407) provides that the Secretary of the Army may permit the discharge of refuse into navigable waters, when it is determined by the USACE that anchorage and navigation will not be injured thereby.

Section 14 of the Rivers and Harbors Act of 1899 (33 U.S.C. 408) provides that the Secretary of the Army, upon recommendation from the USACE, may grant permission for the temporary occupation or use of any seawall, bulkhead, jetty, dike, levee, wharf, pier, or other work built by the United States.

Section 404 of the Clean Water Act (33 U.S.C. 1344) authorizes the Secretary of the Army, acting through the USACE, to issue permits for the discharge of dredged or fill material into waters of the United States at specified disposal sites.

Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended (33 U.S.C. 1413) authorizes the Secretary of the Army, acting through the USACE, to issue permits for the transportation of dredged material for the purpose of disposal in the ocean where it is determined that the disposal will not unreasonably degrade or endanger human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities.

Other related laws may also be pertinent to the processing of applications for USACE permits. These laws include Section 401 of the Clean Water Act, the Coastal Zone Management Act of 1972, Section 302 of the Marine Protection, Research and Sanctuaries Act of 1972, the National Environmental Policy Act of 1969, the Fish and Wildlife Act of 1956, the Fish and Wildlife Coordination Act, the Federal Power Act of 1920, the National Historic Preservation Act of 1966, the Interstate Land Sales Full Disclosure Act, the Endangered Species Act, the Deepwater Port Act of 1974, the Marine Mammal Protection Act of 1972, Section 7a of the Wild and Scenic Rivers Act, the Ocean Thermal Energy Conversion Act of 1980, Section 402 of the Clean Water Act, and the National Fishing Enhancement Act of 1984.

The USACE regulatory program is further described in 33 Code of Federal Regulations (CFR) Parts 320 through 330 available through the Government Printing Office, Washington, DC.

REGULATORY AUTHORITY OF THE STATE GOVERNMENT

Regulatory authority and responsibilities of the State of Maryland are primarily concerned with the following laws:

Under Section 401 of the Clean Water Act, the State of Maryland is required to issue a Water Quality Certification for any federally permitted activity which may result in a discharge of dredged or fill material to State waters or wetlands. This Water Quality

Certification indicates that the activity will not cause a violation of the State water quality standards or limitations.

The Wetlands Law (Title 9 of the Natural Resources Article of the Annotated Code of Maryland) requires property owners to obtain permission from the State of Maryland either through a Wetlands License issued by the State Board of Public Works and/or a Wetlands Permit, or approval granted by the Department of Natural Resources, before altering tidal wetlands or allowing the discharge of storm water.

Section 307 of the Coastal Zone Management Act requires that federally permitted activities be consistent with the State's Coastal Zone Management Program. Applicants for federal permits must certify that their project is consistent with the Coastal Zone Management Program. The State of Maryland is required to concur or disagree with this certification.

Section 8-803 of the Natural Resources Article of the Annotated Code of Maryland requires that a non-tidal waterway construction permit shall be obtained from the Department of Natural Resources for any construction in the 100-year floodplain which alters the course, current, or cross-section of a stream or body of water within the State.

Sections 8-1201 through 8-1211 of the Natural Resources Article of the Annotated Code of Maryland require that a nontidal wetland permit shall be obtained from the Department of Natural Resources for grading, filling, excavating, destroying or removing vegetation, altering the water level, or placing structures in a nontidal wetland or its 25 ft buffer or 100 ft expanded buffer.

SUBMITTING A PERMIT APPLICATION

An applicant for a license or permit should complete and submit a "Joint Federal/State Application for the Alteration of any Floodplain, Waterway, Tidal or Non-Tidal Wetland in Maryland." The application form is jointly accepted and processed by all State and Federal regulatory agencies. If the proposed activity will take place in nontidal wetlands, the applicant should include a wetland delineation with the Joint Federal/State Application.

The information on the application will be used to determine the proper form of authorization and to evaluate the submitted proposal. Some types of activities have been previously authorized by the USACE through general permits. However, individual State permits, licenses, or approvals are also required for all projects. Additionally, it may be necessary to obtain certain local permits. Water Quality Certification or Coastal Zone Consistency Statements may be required by the USACE for processing Federal permits. The applicant is responsible for obtaining all proper approvals for a particular project proposal prior to the commencement of work.

A Public Notice may be required to notify Federal, State, and local agencies, adjacent property owners, and the general public of the proposal, allowing sufficient opportunity for review and comment on the proposed work. The applicant's proposal and all relevant information, including public comments, will be reviewed considering anticipated benefits versus potential negative impacts of the proposed work.

A sample application form is shown in Figure 17. The application form can be obtained from any of the regulatory agencies listed below:

FEDERAL

U.S. Army Engineer District, Baltimore
ATTN: CENAB-OP-R
P.O. Box 1715
Baltimore, MD 21203-1715
Telephone: (410) 962-3670

STATE

Department of Natural Resources
Water Resources Administration
Tidal Wetlands Division
Tawes State Office Building
Taylor Avenue
Annapolis, MD 21401
Telephone: (410) 974-3871

Department of Natural Resources
Water Resources Administration
Waterway Permits Division
Tawes State Office Building
Taylor Avenue
Annapolis, MD 21401
Telephone: (410) 974-2265

Department of Natural Resources
Water Resources Administration
Nontidal Wetlands Division
Tawes State Office Building
Taylor Avenue
Annapolis, MD 21401
Telephone: (410) 974-3841

Materials and information for a Coastal Zone Consistency Statement or a Water Quality Certificate may be obtained from the agencies shown below.

COASTAL ZONE CONSISTENCY STATEMENT

Department of Natural Resources
Water Resources Administration
Wetlands and Waterways Program
Tawes State Office Building
Taylor Avenue
Annapolis, MD 21401
Telephone: (410) 974-2156

WATER QUALITY CERTIFICATION

Department of the Environment
Water Management Administration
Division of Standards and Certification
2500 Broening Highway
Baltimore, MD 21224
(410) 631-3609

Completed applications should be mailed to:

Central Processing Unit
Wetlands and Waterways Program
Water Resources Administration
Tawes State Office Building
Taylor Avenue
Annapolis, MD 21401
Telephone: (800) 876-0200

TYPICAL PROCEDURE FOR PROCESSING PERMIT APPLICATIONS

This section describes the typical procedure used to process a submitted application. For additional information on the evaluation process, application form, or status of a submitted application, contact the Central Processing Unit, Wetlands and Waterways Program at the address and telephone listed above. The typical processing procedure involves the following steps:

1a. Applicant submits completed Joint Federal/State Application form to the Central Processing Unit.

1b. Application is received, assigned an identification number, and an acknowledgement is sent to the applicant. Application is circulated to the various regulatory agencies.

2a. Central Processing Office may require additional information to complete the application and/or correct delineation if necessary. Notification that additional information is required is typically sent within 45 days of receipt of application.

2b. Applicant submits additional information if required and/or corrects delineation if necessary.

2c. Notification is sent that application is complete and/or delineation is correct.

3. State nontidal wetland letter of exemption is issued if project qualifies (Department of the Army authorization may still be required) or activity determined to require permit.

4. If required, public notice is issued upon receipt of all information. Depending on the type of activity proposed, 15 to 30 days are alloted for submission of comments in response to the public notice.

5. The proposal is reviewed by the public, special interest groups, and local, State, and Federal agencies.

6. All comments are considered.

7. Other agencies are consulted if deemed appropriate or required.

8. Regulatory agencies may ask the applicant to provide additional information.

9. A public hearing may be held if necessary.

10. The permit may be issued as applied for; or the agencies may modify the application request, in conjunction with the applicant, to make the project more acceptable; or the permit may be denied with the appropriate reason(s) explained to the applicant.

FACTORS AND POLICIES FOR EVALUATING APPLICATIONS

Each permit application is evaluated based on the probable impacts, including cumulative impacts, of the proposed activity versus its potential benefits for the public interest. The decision to grant or deny a permit is based on the balancing of benefits expected from the proposed work against the potential detrimental impacts. All relevant factors must be considered in the decision including conservation, economics, aesthetics, general environmental concerns, developmental factors, wetlands, historic properties, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shoreline erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs, property ownership considerations, and the general needs and welfare of the people (Federal Register 1986). Additionally, if the proposal involves the discharge of dredged or fill material, the USACE must evaluate the proposed activity's compliance with the Environmental Protection Agency's Section 404(b)(1) guidelines.

The general criteria to be considered in the evaluation of every application include: the relative extent of the public and private need for the proposed structure or activity; if conflicts are involved, the practicability of using reasonable alternative locations and methods to accomplish the objective of the proposed structure or activity; and the extent and permanence of the beneficial and/or detrimental effects which the proposed structure or activity is likely to have on the public and private uses to which the area is suited.

The specific weight of each evaluation factor is determined by its importance and relevance to a particular proposal. Accordingly, the amount of consideration given to an individual factor will vary with each proposal. Full consideration and appropriate weight, however, will be given to all comments from all involved agencies.

JOINT FEDERAL / STATE APPLICATION FOR THE ALTERATION OF ANY FLOODPLAIN, WATERWAY, TIDAL OR NONTIDAL WETLAND IN MARYLAND

FOR AGENCY USE ONLY

Application number____________________ **Date Determined Complete**____________________

Date received by State____________________ **Date(s) Returned**____________________

Date received by Corps____________________ ____________________

Type of State permit needed____________________ **Date of Field Review**____________________

Type of Corps permit needed____________________ Agency Performed Field Review____________________

++

- Please submit 1 original and 4 copies of this form, required maps and plans to the Wetlands and Waterways Program as noted on the last page of this form.
- Any application which is not completed in full or is accompanied by poor quality drawings may be considered incomplete and result in a time delay to the applicant.

Please check one of the following:

RESUBMITTAL:____ APPLICATION AMENDMENT:____ MODIFICATION TO AN EXISTING PERMIT:___
JURISDICTIONAL DETERMINATION ONLY___ APPLYING FOR AUTHORIZATION_____
PREVIOUSLY ASSIGNED NUMBER (RESUBMITTALS AND AMENDMENTS)____________________
DATE____________________

1. APPLICANT INFORMATION:

APPLICANT NAME:

A. Name: ____________________ B. Daytime Telephone: (______) ________________
C. Company: ____________________
D. Address: ____________________
E. City: ____________________ State: __________ Zip: ________________

AGENT/ENGINEER INFORMATION:

A. Name: ____________________ B. Telephone: (______) ________________
C. Company: ____________________
D. Address: ____________________
E. City: ____________________ State: __________ Zip: ________________

ENVIRONMENTAL CONSULTANT:

A. Name: ____________________ B. Telephone: (______) ________________
C. Company: ____________________
D. Address: ____________________
E. City: ____________________ State: __________ Zip: ________________

CONTRACTOR (If Known): ____________________

A. Name: ____________________ B. Telephone: (______) ________________
C. Company: ____________________
D. Address: ____________________
E. City: ____________________ State:__________ Zip: ________________

PRINCIPAL CONTACT:

A. Name: ____________________ B. Telephone: (______) ________________
C. Company:____________________
D. Address:____________________
E. City:____________________ State:__________ Zip: ________________

Figure 17. Sample application form (Continued).

2. PROJECT DESCRIPTION:
a. GIVE WRITTEN DESCRIPTION OF PROJECT:

____
____
____

Has any portion of the project been completed? ____Yes ____No If yes, explain ________________________
____
____

b. ACTIVITY: Check all activities that are proposed in the wetland, waterway, floodplain, and nontidal wetland buffer as appropriate.

A_____filling
B_____dredging
C_____excavating
D_____flooding or impounding water
E_____draining
F_____grading
G_____removing or destroying vegetation
H_____building structures

Area for item(s) checked: Wetland __________(sq. ft.) Buffer (Nontidal Wetland Only) ____________(sq. ft.)
Expanded Buffer (Nontidal Wetland Only) ______________________(sq. ft.)

Length of stream affected ______________(linear feet)

c. TYPE OF PROJECTS: Project Dimensions

For each activity, give overall length and width (in feet), in columns 1 and 2. For multiple activities, give total area of disturbance in square feet in column 3. For activities in tidal waters, give maximum distance channelward (in feet) in column 4. For dam or small ponds, give average depth (in feet) for the completed project in column 5. Give the volume of fill or dredged material in column 6.

	Length (Ft.)	Width (Ft.)	Area Sq. Ft.	Maximum / Average Channelward Encroachment		Pond Depth	Volume of fill/dredge material (cubic yards) below MHW or OHW
	1	2	3	4		5	6
A.____ Bulkhead*	____	____		____	____		____
B.____ Revetment*	____	____		____			____
C.____ Vegetative Stabilization	____	____		____	____		____
D.____ Gabions	____	____		____	____		____
E.____ Groins	____	____		____	____		____
F.____ Jetties	____	____		____	____		____
G.____ Boat Ramp	____	____		____	____		____
H.____ Pier*	____	____		____	____		
I.____ Breakwater	____	____		____	____		____
J.____ Repair & Maintenance	____	____	____	____	____		____
K.____ Road Crossing	____	____	____				____
L.____ Utility Line	____	____	____				____
M.____ Outfall Construction	____	____	____	____	____		____
N.____ Small Pond	____	____	____			____	____
O.____ Dam	____	____	____			____	____
P.____ Lot Fill	____	____	____				____
Q.____ Building Structures	____	____	____	____	____		____
R.____ Culvert	____	____	____				____
S.____ Bridge	____	____	____	____	____		____
T.____ Stream Channelization	____	____	____				____
U.____ Parking Area	____	____	____				____
V.____ Dredging*	____	____	____	____	____		____

1 _____ New 2 _____ Maintenance 3 _____ Hydraulic 4 _____ Mechanical
W._____ Other (explain)____

****** For projects indicated with an asterisk refer to the sample plans and checklists found in the January, 1988 Joint Application booklet.

2

Figure 17. Sample application form (Continued).

d. PROJECT PURPOSE: Give brief written description of the project purpose:

____

____

____

____

____

____

____

3. PROJECT LOCATION:

a. LOCATION INFORMATION

A. County: ____________ B. City: ______________ C. Name of waterway or closest waterway ________________
D. State stream use class designation: ____
E. Site Address or Location: ____

____

F. Directions from nearest intersection of two state roads: __________________________________

____

____

____

G. Is your project located in the Chesapeake Bay Critical Area (generally within 1000 feet of tidal waters or tidal wetlands)?:
_____Yes _____No
H. County Book Map Coordinates (Alexandria Drafting Co.); Excluding Garrett and Somerset Counties:
Page: __________ Letter: ________ Number: __________ (to the nearest tenth)
I. FEMA Floodplain Map Panel Number (If Known): ________
J. 1___________latitude 2___________longitude

b. ACTIVITY LOCATION: Check one or more of the following as appropriate for the type of wetland/waterway where you are proposing an activity:

A_____ Tidal Waters
B_____ Tidal Wetlands
C_____ Special Aquatic Site (e.g., mudflat, vegetated shallows)
D_____ Nontidal Wetland
E_____ 25-foot buffer(nontidal wetlands only)

F_____100-foot buffer (nontidal wetland of special State concern)
G_____ In stream channel
1___Tidal 2___Nontidal

H_____100-year floodplain (outside stream channel)
I_____River, lake, pond
J_____Other (Explain)______

____

____

c. LAND USE:

A. Current Use Of Parcel Is: 1_____ Agriculture: Has SCS designated project site as a prior converted cropland?
_____ Yes ____No 2_____ Wooded 3_____ Marsh/Swamp 4_____ Developed
5 _____Other(explain)____

B. Present Zoning Is: 1_____ Residential 2_____ Commercial/Industrial 3_____ Agriculture 4_____ Marina 5___Other

C. Project complies with current zoning _____ Yes _____ No

THE FOLLOWING INFORMATION IS REQUIRED BY THE STATE (blocks 4-7):
Note: If you are proposing activities in nontidal wetlands, their buffers, or expanded buffers in the Chesapeake Bay Critical Area do not complete these blocks.

4. REDUCTION OF IMPACTS: Explain measures taken or considered to avoid or minimize wetlands losses in F. Also check items A-E if any of these apply to your project.

A. _____ Reduced the area of disturbance
B. _____ Reduced size/scope of project
C. _____ Relocated structures
D. _____ Redesigned project

E. _____ Other ____

3

Figure 17. Sample application form (Continued).

F. Explanation ____
____

Describe reasons why impacts were not avoided or reduced in Q. Also check items G-P that apply to your project.

G. _____ Cost
H. _____ Extensive wetlands on site
I. _____ Engineering/design constraints
J. _____ Other natural features

K. _____ Parcel size
L. _____ Other regulatory requirement
M. _____ Failure to accomplish project purpose

N. _____ Safety/public welfare issue
O. _____ Inadequate zoning
P. _____ Other___________
____
____

Q. Description ____
____
____

5. LETTER OF EXEMPTION: If you are applying for a letter of exemption for activities in nontidal wetlands and/or their buffers, explain why the project qualifies:

A. _____ No significant plant or wildlife value and wetland impact:
  1. _____ Less than 5,000 square feet
  2. _____ In an isolated nontidal wetland less than 1 acre in size

B. _____ Repair existing structure/fill
C. _____ Mitigation Project
D. _____ Utility Line
  1_____overhead
  2_____underground

E. _____ Other (explain) ____
____
____

F. _____ Check here if you are **not** applying for a letter of exemption

IF YOU ARE APPLYING FOR A LETTER OF EXEMPTION, PROCEED TO BLOCK 11

6. ALTERNATIVE SITE ANALYSIS: Explain why other sites that were considered for this project were rejected in N. Also check any items in E-M if they apply to your project. **(If you are applying for a letter of exemption, do not complete this block):**

A. _____ 1 site
B. _____ 2 - 4 sites
C. _____ 5 or more sites

Alternative sites were rejected/not considered for the following reason(s):

D. _____ Cost
E. _____ Lack of availability
F. _____ Failure to meet project purpose
G. _____ Located outside general/market area

H. _____ Greater wetlands impact
I. _____ Water dependency
J. _____ Inadequate zoning
K. _____ Engineering/design constraints

L. _____ Other __________
____
____
____
____

M. Explanation ____
____
____

7. PUBLIC NEED: Describe the public need or benefits that the project will provide in F. Also check items in A-E that apply to your project. **(If you are applying for a letter of exemption, do not complete this block):**

A. _____ Economic
B. _____ Safety

C. _____ Health/welfare
D. _____ Does not provide public benefits

E. _____ Other _____________
____

F. Description ____
____

4

Figure 17. Sample application form (Continued).

8. **OTHER APPROVALS NEEDED/GRANTED:**

A. Agency	B. Date Sought	C. Decision 1. Granted	2. Denied	D. Decision Date	E. Other Status
______	______	____	____	____	____
______	______	____	____	____	____
______	______	____	____	____	____
______	______	____	____	____	____
______	______	____	____	____	____
______	______	____	____	____	____

9. **MITIGATION PLAN:** Please provide the following information:

a. Description of a monetary compensation proposal, if applicable (For **State requirements** only). Attach another sheet if necessary. ______

b. Give a brief description of the proposed mitigation project. ______

c. Describe why you selected your proposed mitigation site, including what other areas were considered and why they were rejected. ______

d. Describe how the mitigation site will be protected in the future. ______

10. **HAVE ADJACENT PROPERTY OWNERS BEEN NOTIFIED?:** A____ Yes B____ No

Provide names and mailing addresses below (Use separate sheet if necessary):

a.______ b.______ c.______

5

Figure 17. Sample application form (Continued).

11. **HISTORIC PROPERTIES:** Is your project located in the vicinity of historic properties? (For example: structures over 50 years old, archeological sites, shell mounds, Indian or Colonial artifacts). Provide any supplemental information in section 13.

A. ____ Yes B. ____ No C. ____ Unknown

12. **ADDITIONAL INFORMATION:** Use this space for detailed responses to any of the previous items. Attach another sheet if necessary:

____

____

____

Check box if data is enclosed for any one or more of the following (See checklist for required information):

A_______ Soil borings
B_______ Wetland data sheets
C_______ Photographs
D_______ Field surveys
E_______ Alternative site analysis
F_______ Market analysis
G_______ Site plan
H_______ Avoidance and minimization analysis

I_______ Other (explain)____

____

____

CERTIFICATION:

I hereby designate and authorize the agent named above to act on my behalf in the processing of this application and to furnish any information that is requested. I certify that the information on this form and on the attached plans and specifications is true and accurate to the best of my knowledge and belief. I understand that any of the agencies involved in authorizing the proposed works may request information in addition to that set forth herein as may be deemed appropriate in considering this proposal. I certify that all Waters of the United States have been identified and delineated on site, and that all jurisdictional wetlands have been delineated in accordance with the Federal Manual for Identifying and Delineating Jurisdictional Wetlands. I grant permission to the agencies responsible for authorization of this work, or their duly authorized representative, to enter the project site for inspection purposes during working hours. I will abide by the conditions of the permit or license if issued and will not begin work without the appropriate authorization. I also certify that the proposed works are consistent with Maryland's Coastal Zone Management Plan. I understand that none of the information contained in the application form is confidential and that I may request that additional required information be considered confidential under applicable laws. I further understand that failure of the landowner to sign the application will result in the application being deemed incomplete.

LANDOWNER MUST SIGN: ______________________________ Date:________

6

Figure 17. Sample application form (Concluded).

BIBLIOGRAPHY

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Cox, J. C., 1987. "Breakwater Attenuation Criteria and Specifications for Marina Basins," IMI Marina Design Conference, International Marine Institute, Wickford, RI.

Gaythwaite, J. W., 1990. Design of Marine Facilities for Berthing, Mooring, and Repair of Vessels, Van Nostrand Reinhold, New York, NY.

Shore Protection Manual, 1984. 4th ed. 2 Vols., U. S. Government Printing Office, Washington, D. C.

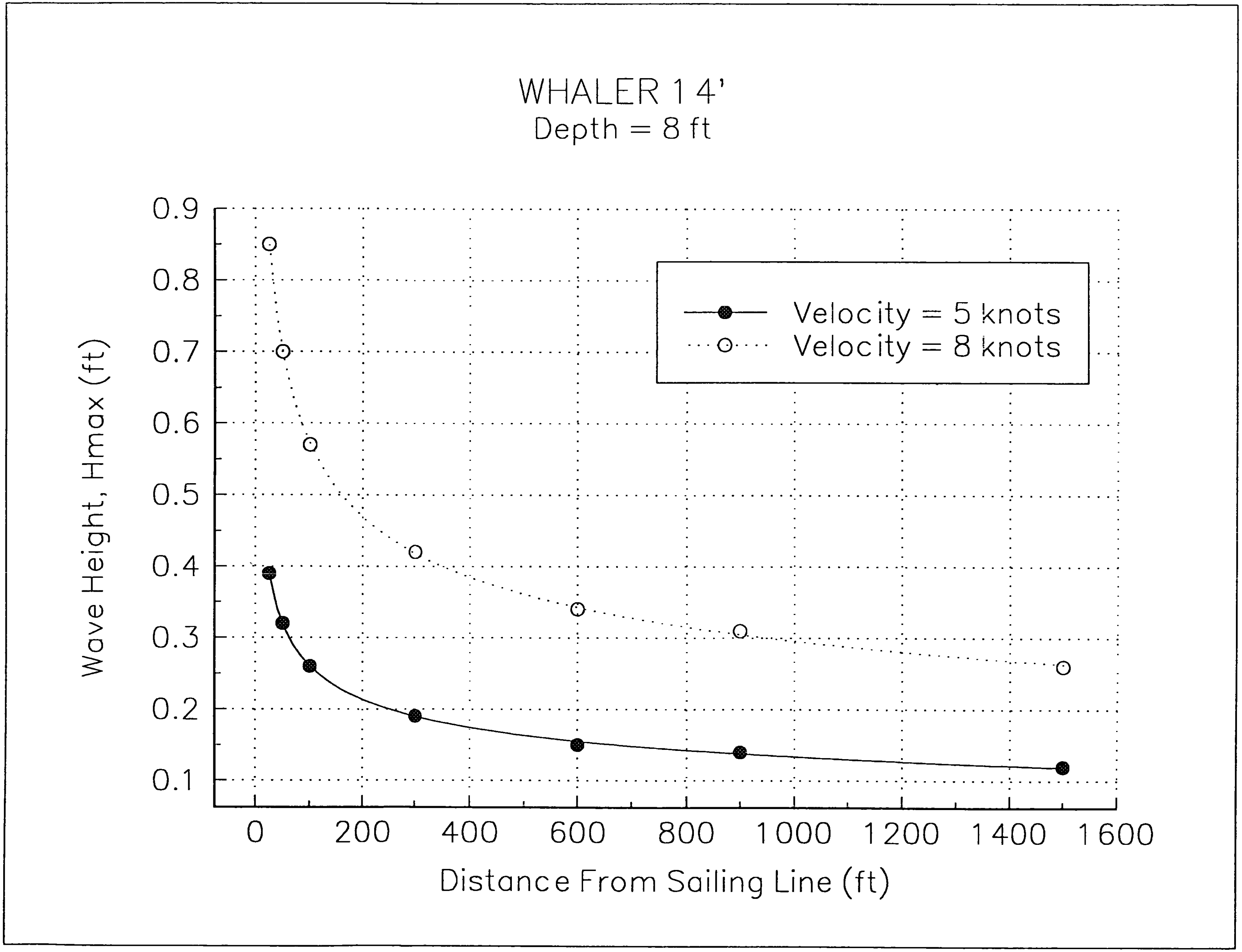
Sorenson, Robert M., 1986. "Bank Protection for Vessel Generated Waves," IMBT Hydraulics Laboratory Report #IHL-117-86, Lehigh University, Bethlehem, PA.

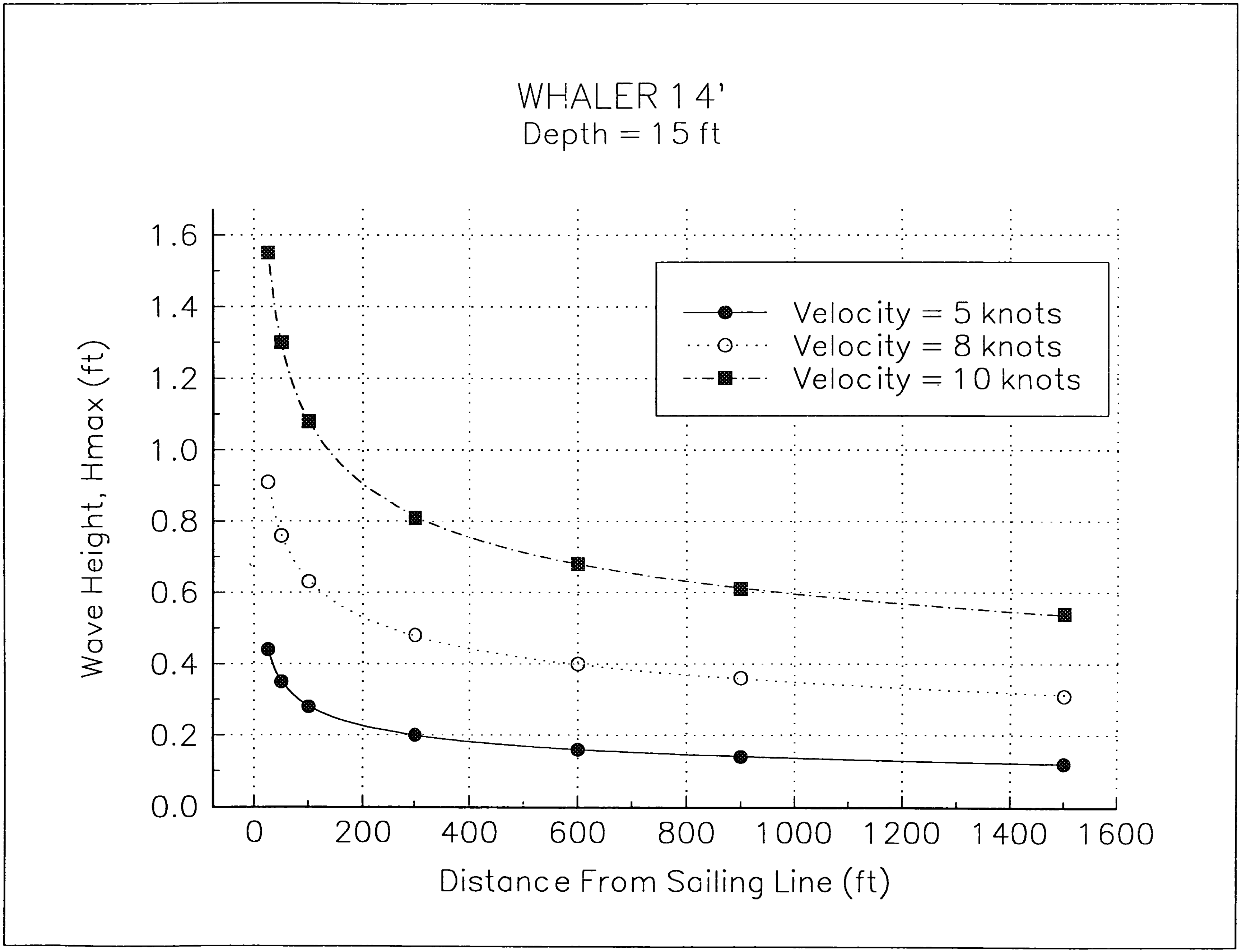
Tobiasson, B. O. and Kollmeyer, R. C., 1991. Marinas and Small-Craft Harbors, Van Nostrand Reinhold, New York, NY.

Appendix A

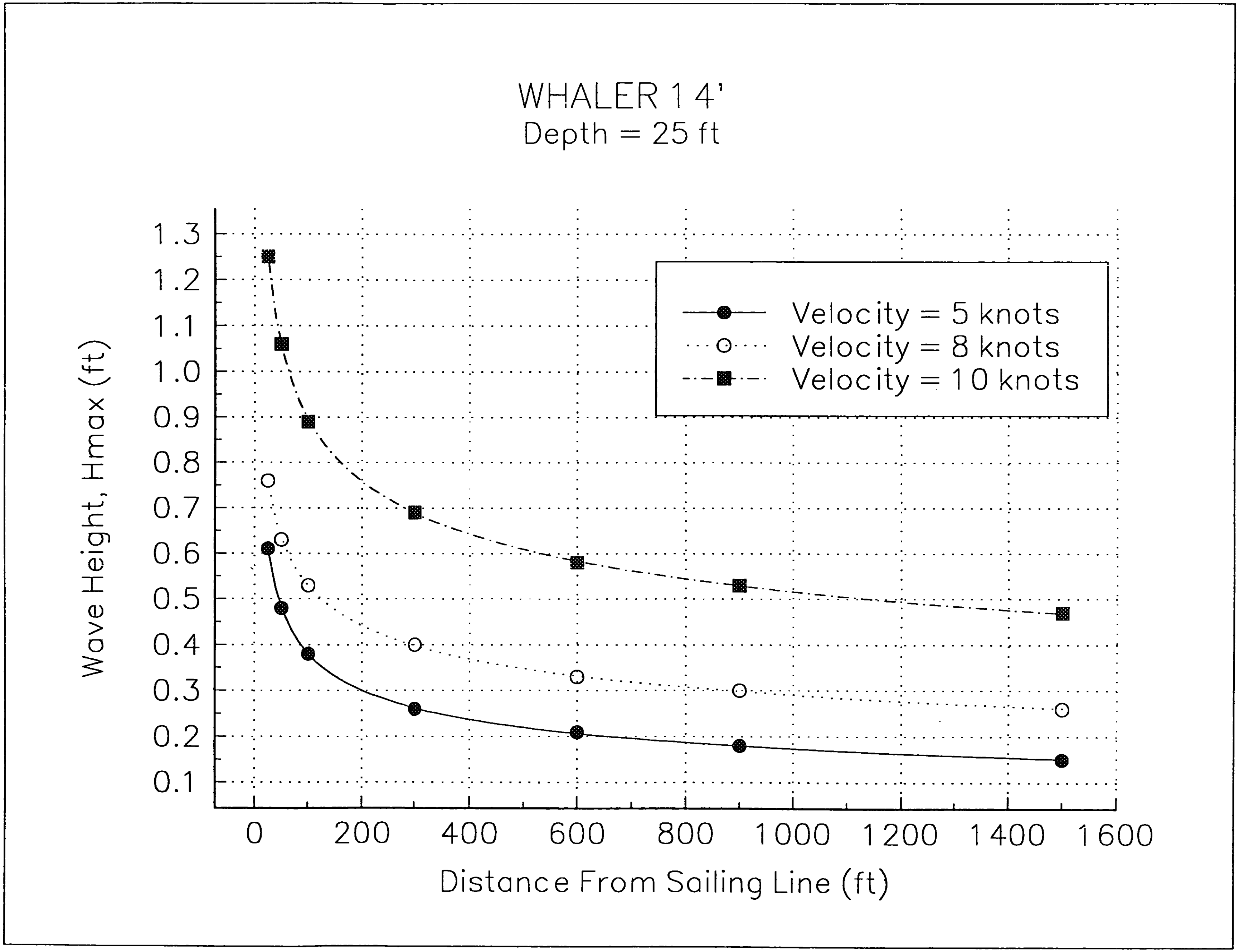
MAXIMUM VESSEL-GENERATED WAVE HEIGHT PREDICTION GRAPHS

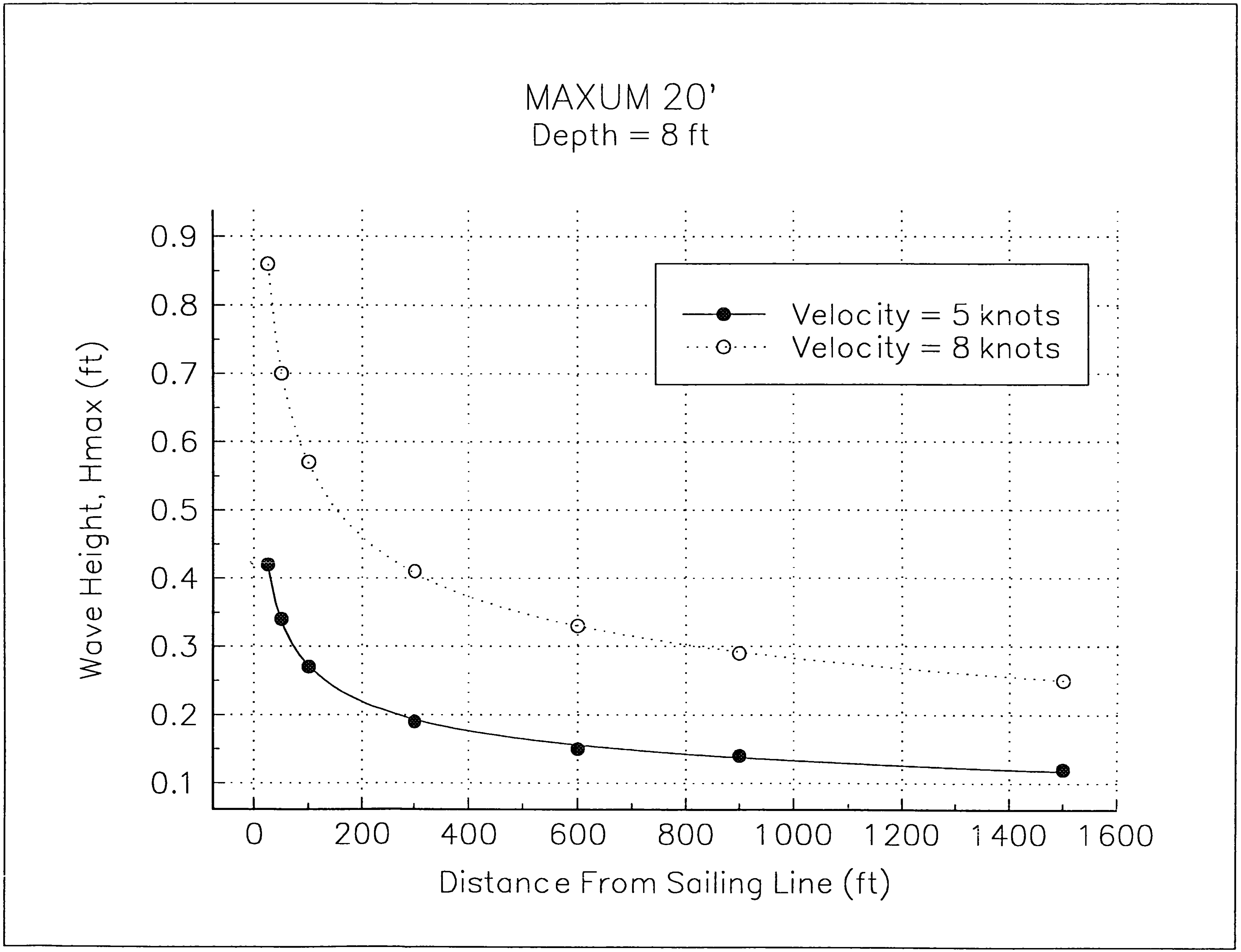
A series of graphs to aid in the prediction of wave heights expected at a marina is presented in this appendix for various recreational vessels. From the graphs, estimated wave heights may be determined at varying distances from the vessel courseline (sailing line) for different vessel speeds. Wave heights provided should not be taken to be exactly the wave that would be produced, but as a guide in determining the magnitude of wave conditions which may occur at a marina for a range of vessels and operating conditions. The vessels shown are the ones listed on page 13 of the main text.

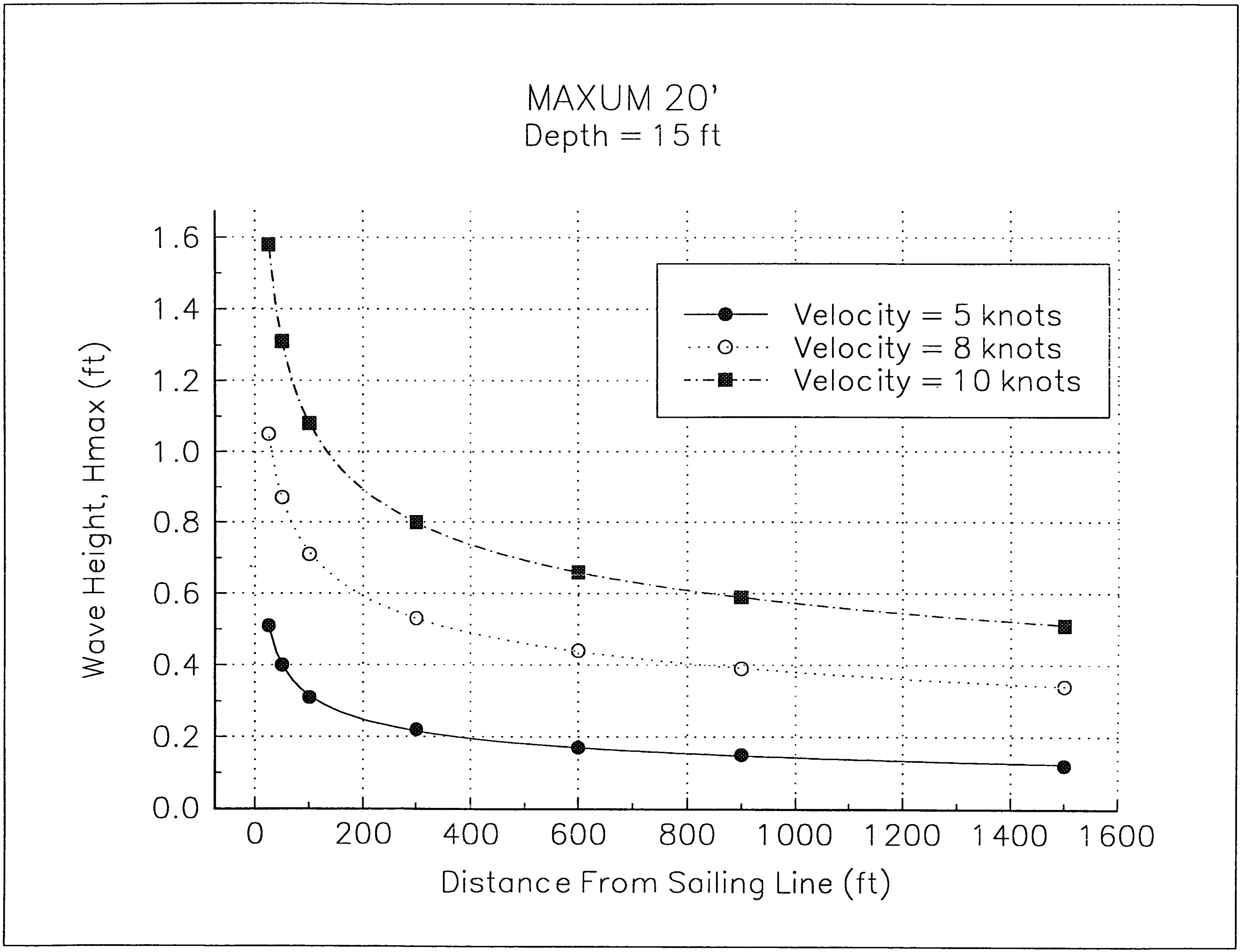

WHALER 14'
Depth = 8 ft
Velocity = 5 knots
Velocity = 8 knots
Wave Height, Hmax (ft)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)

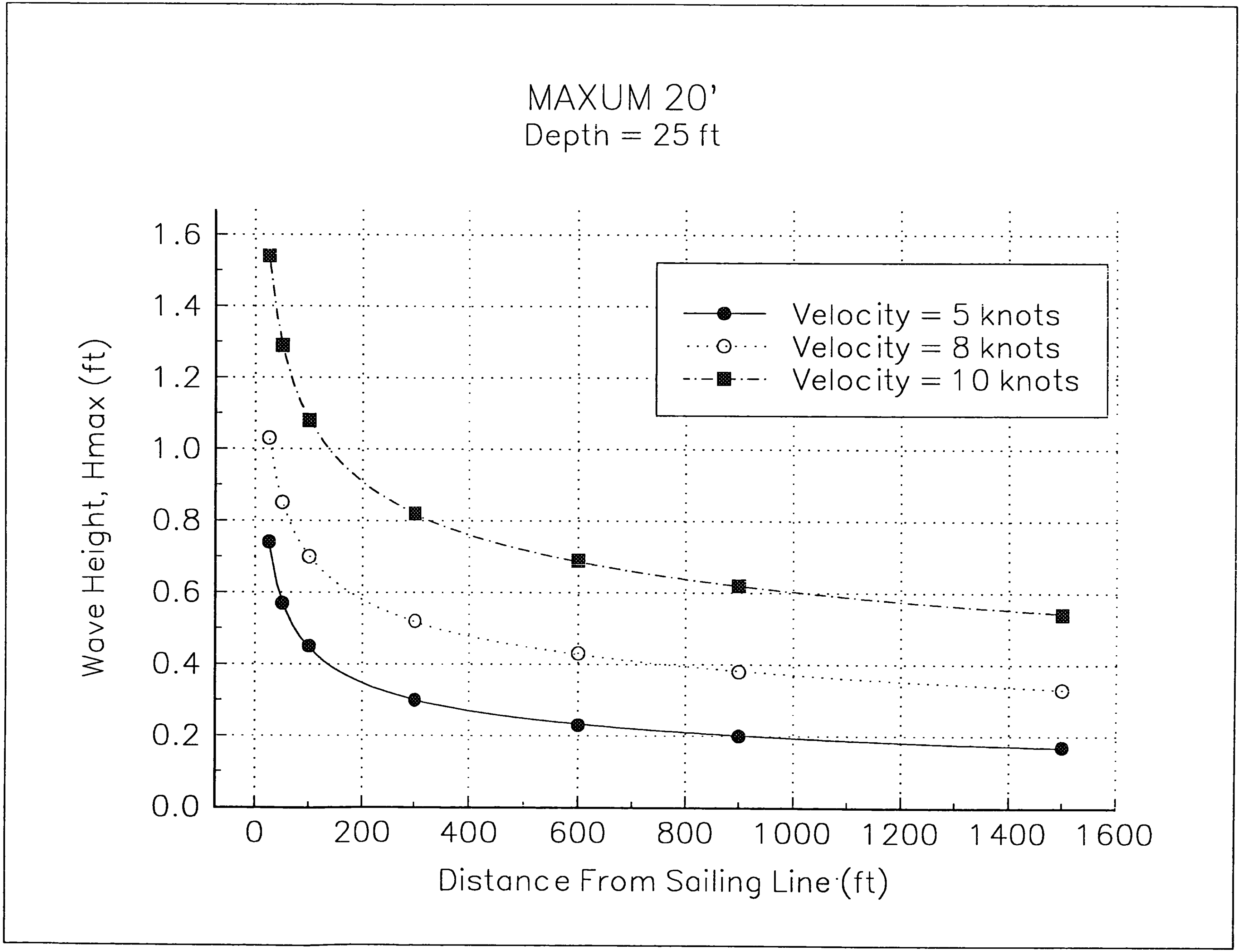


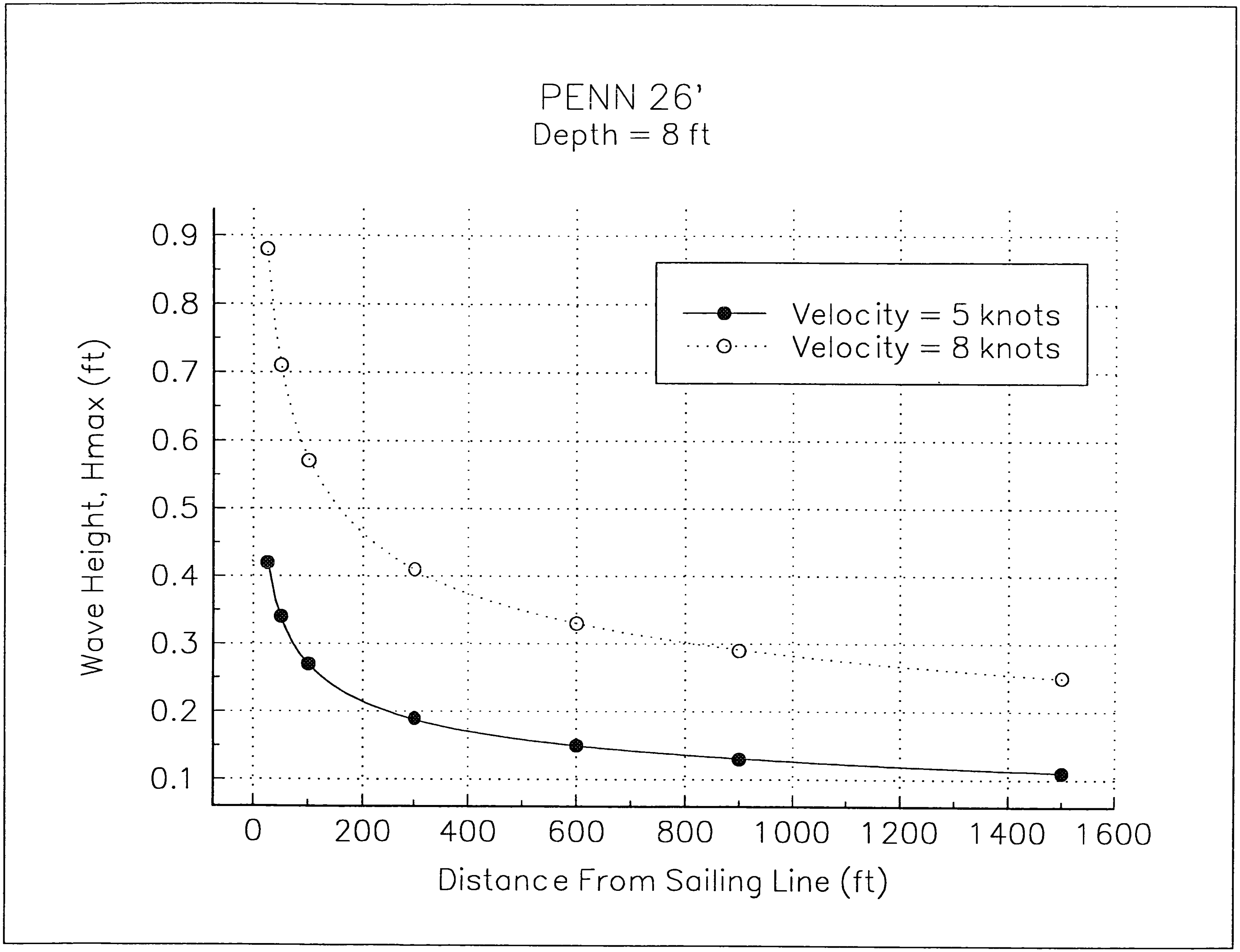
WHALER 14'
Depth = 15 ft
Wave Height, Hmax (ft)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots

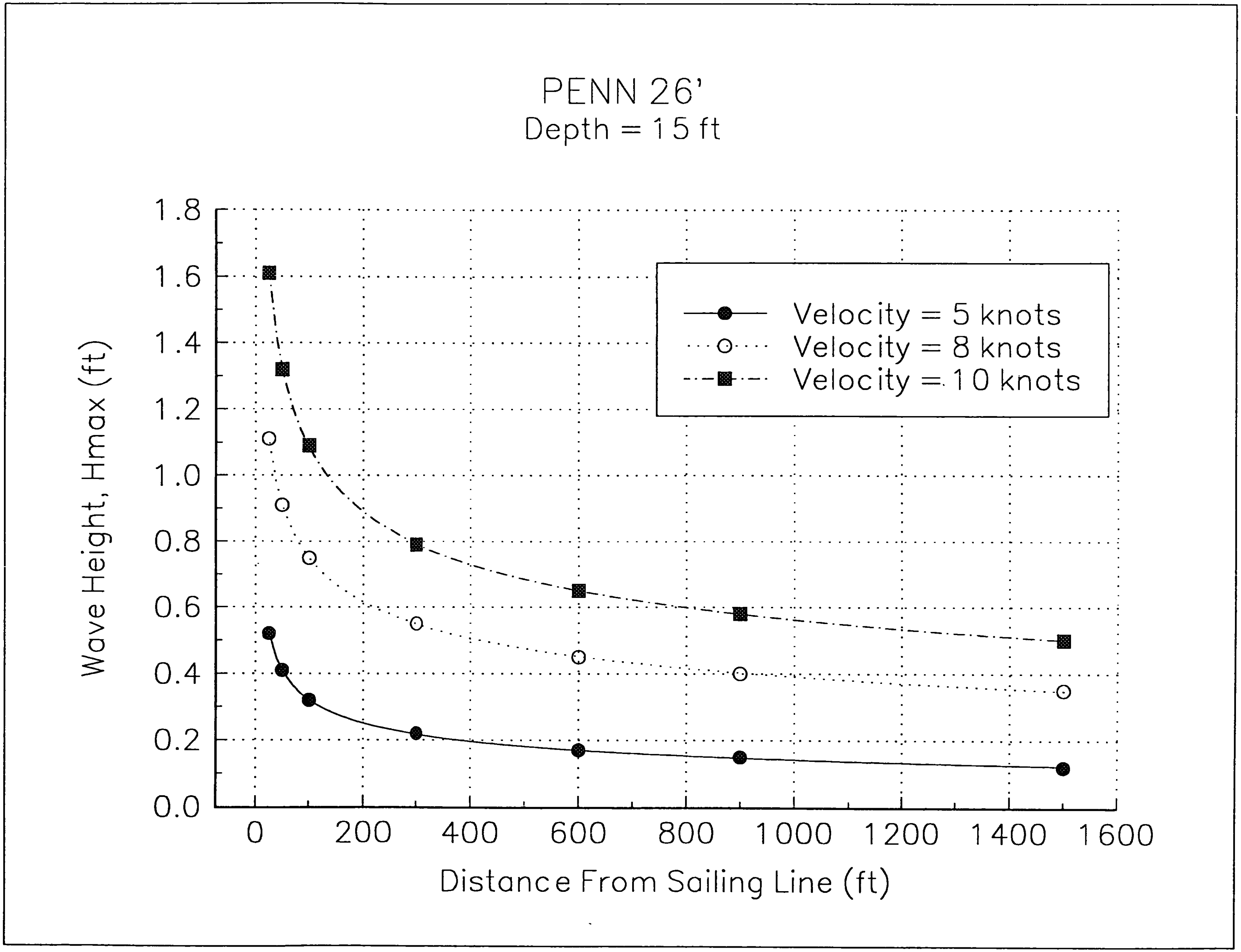

WHALER 14'
Depth = 25 ft
Wave Height, Hmax (ft)
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots

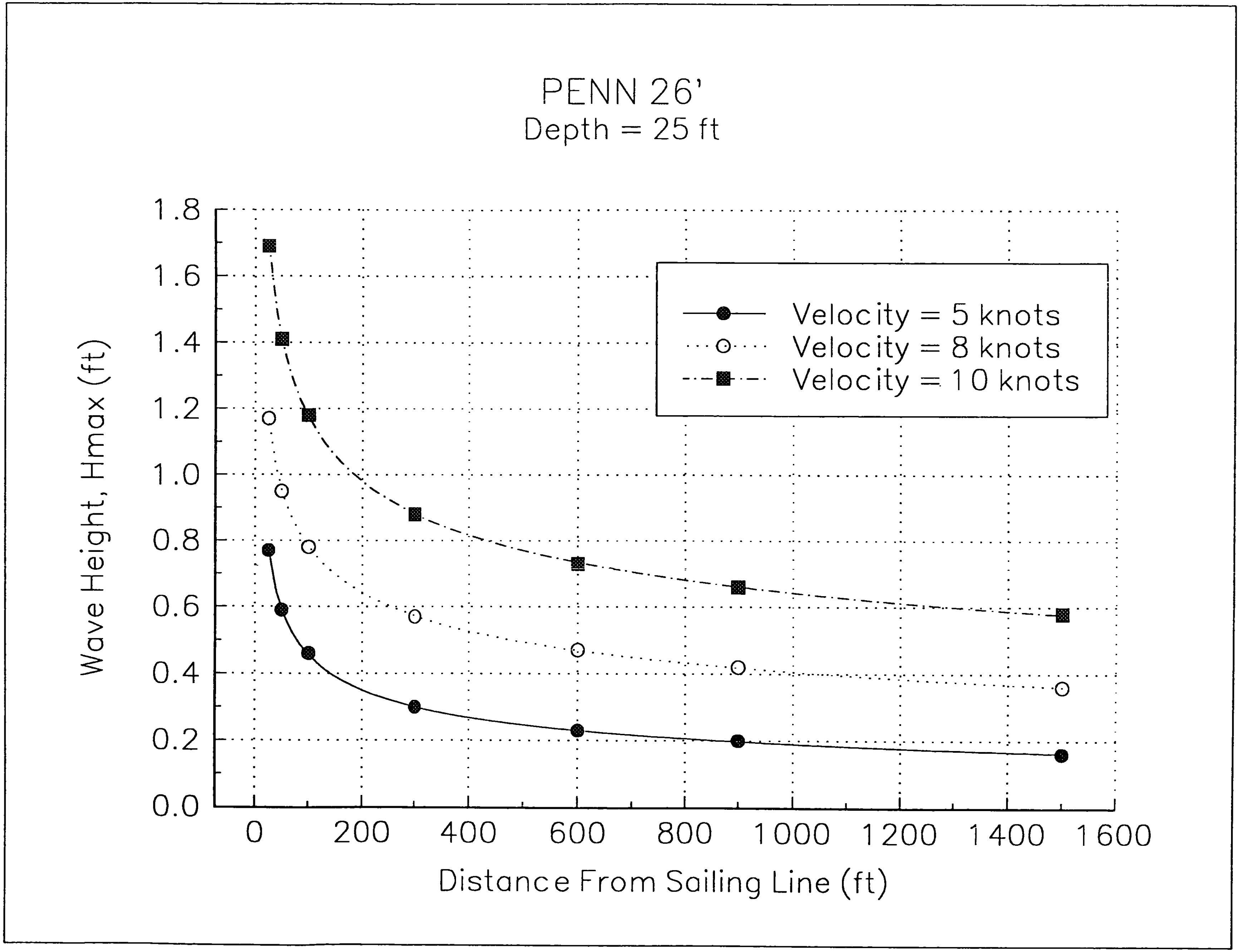

MAXUM 20'
Depth = 8 ft
Velocity = 5 knots
Velocity = 8 knots
Wave Height, Hmax (ft)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)

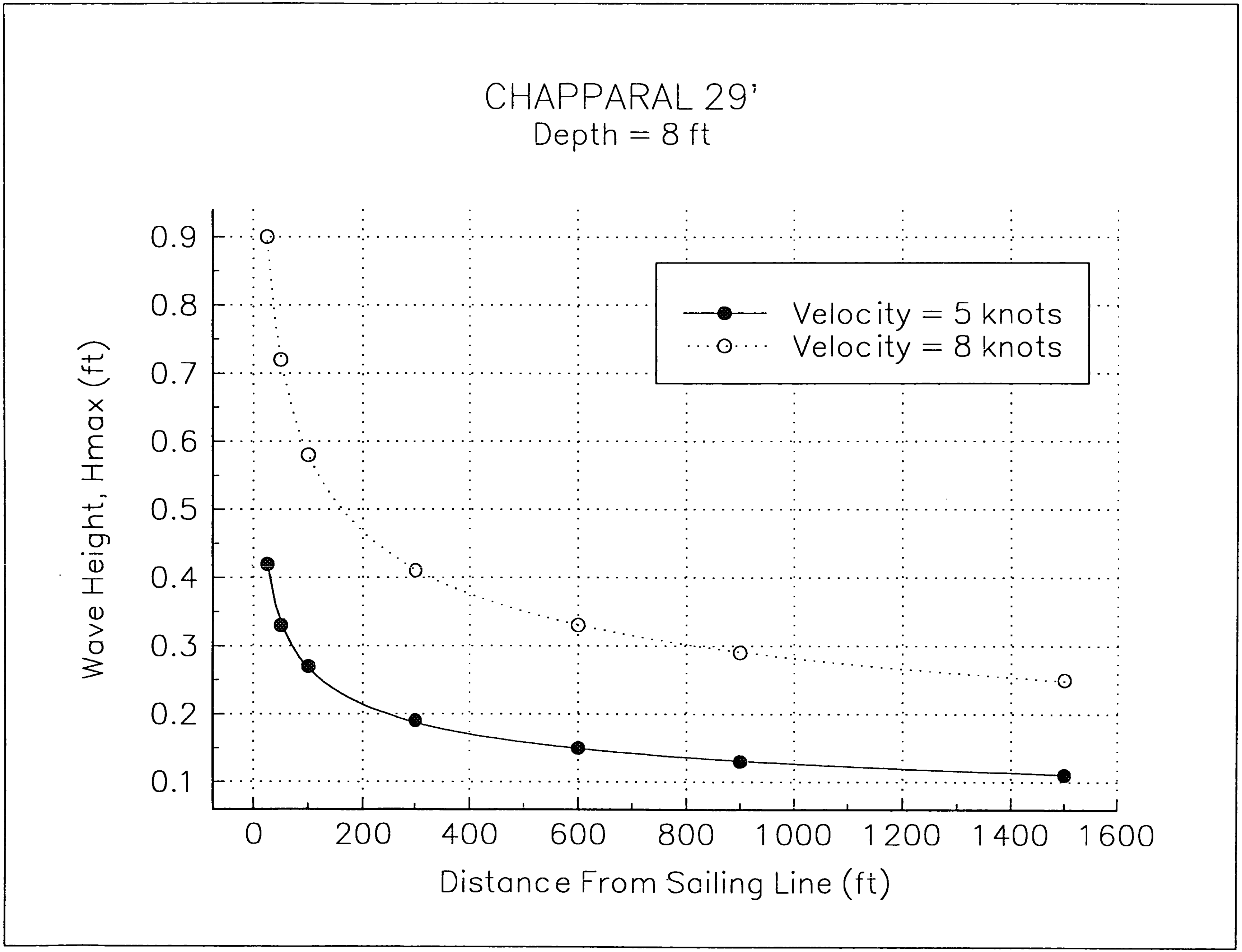

MAXUM 20'
Depth = 15 ft
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots
Wave Height, Hmax (ft)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)

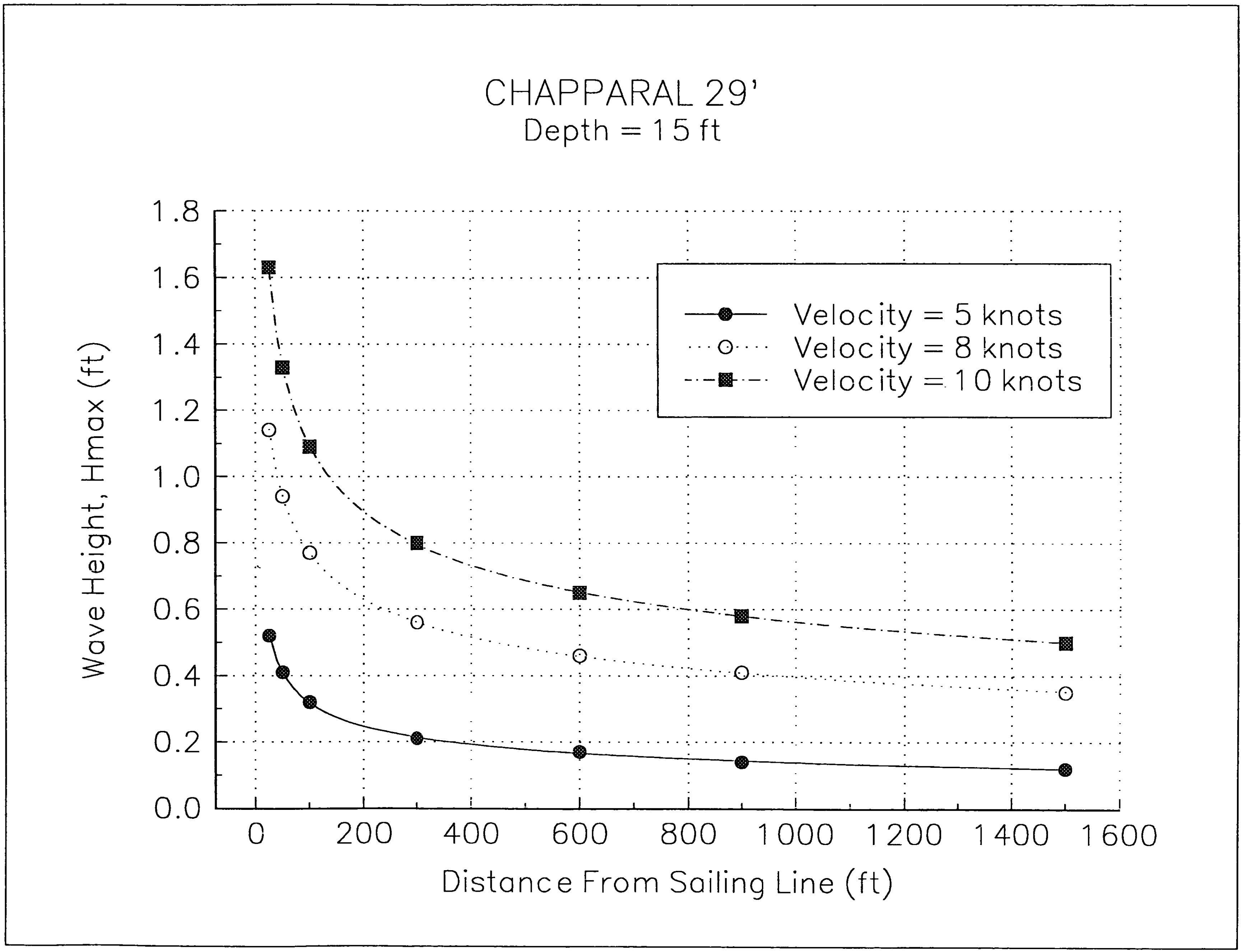

MAXUM 20'
Depth = 25 ft
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots
Wave Height, Hmax (ft)
Distance From Sailing Line (ft)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
200
400
600
800
1000
1200
1400
1600


PENN 26'
Depth = 8 ft
Velocity = 5 knots
Velocity = 8 knots
Wave Height, Hmax (ft)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)

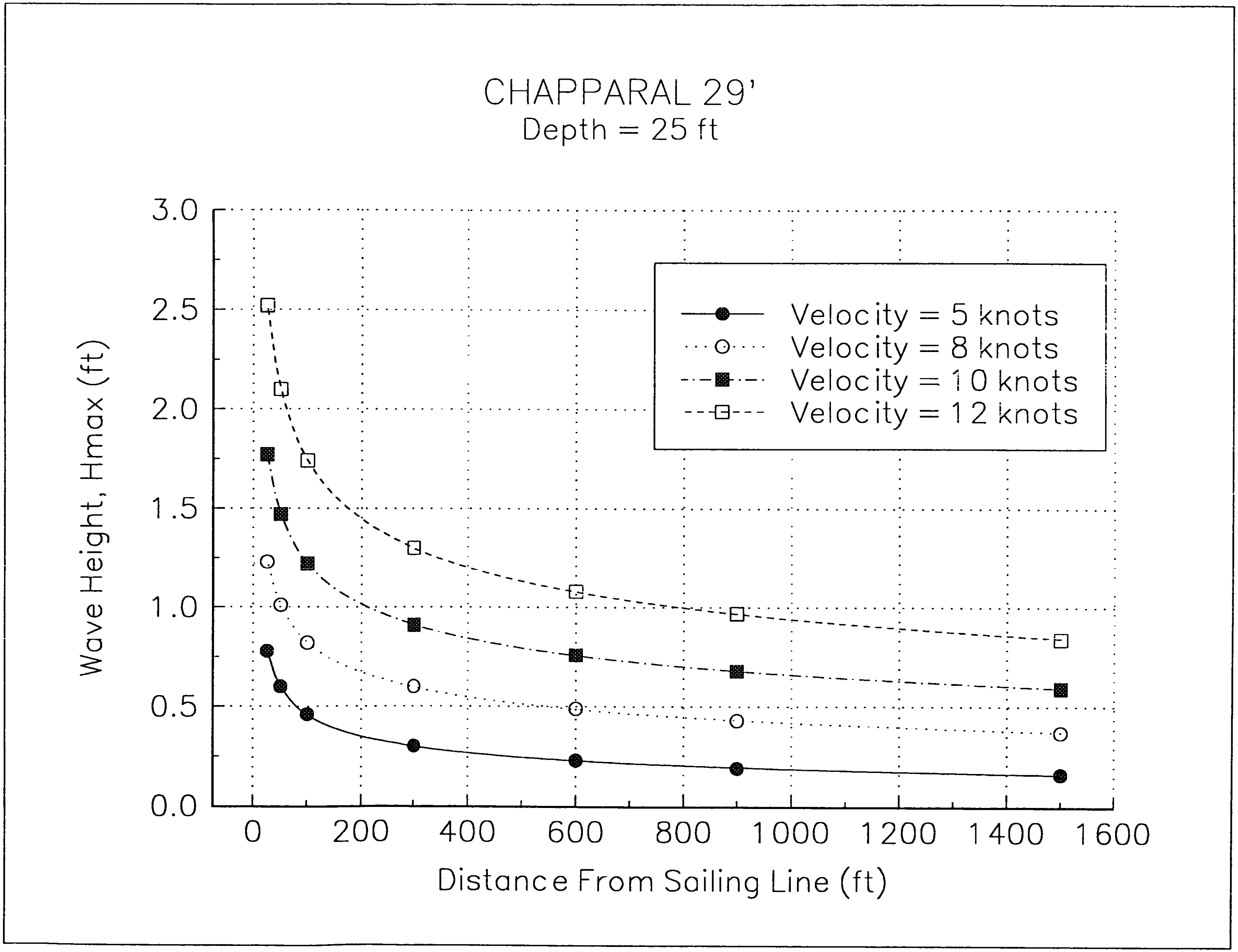

PENN 26'
Depth = 15 ft
Wave Height, Hmax (ft)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Distance From Sailing Line (ft)
0
200
400
600
800
1000
1200
1400
1600
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots

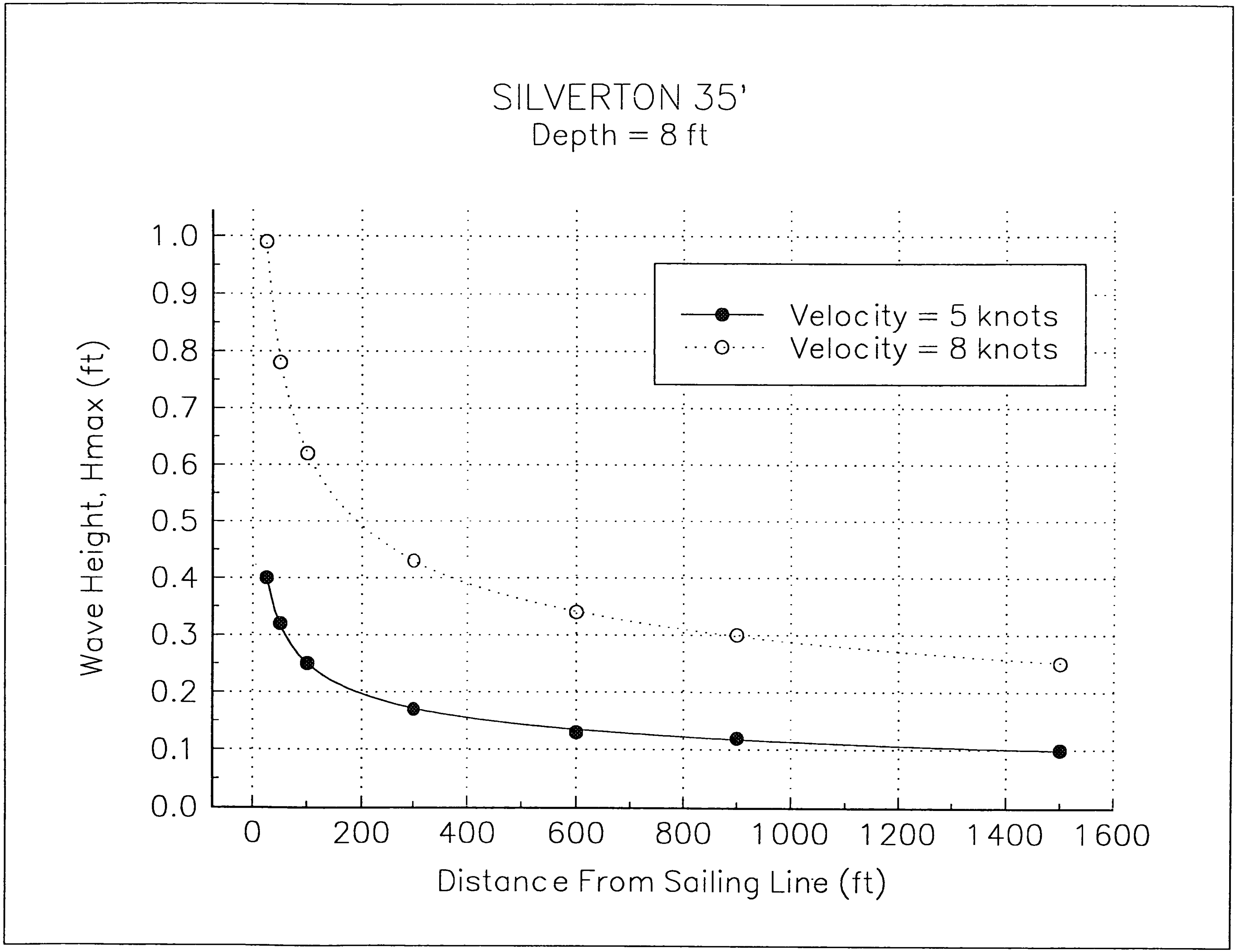

PENN 26'
Depth = 25 ft
Wave Height, Hmax (ft)
Distance From Sailing Line (ft)
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
0
200
400
600
800
1000
1200
1400
1600

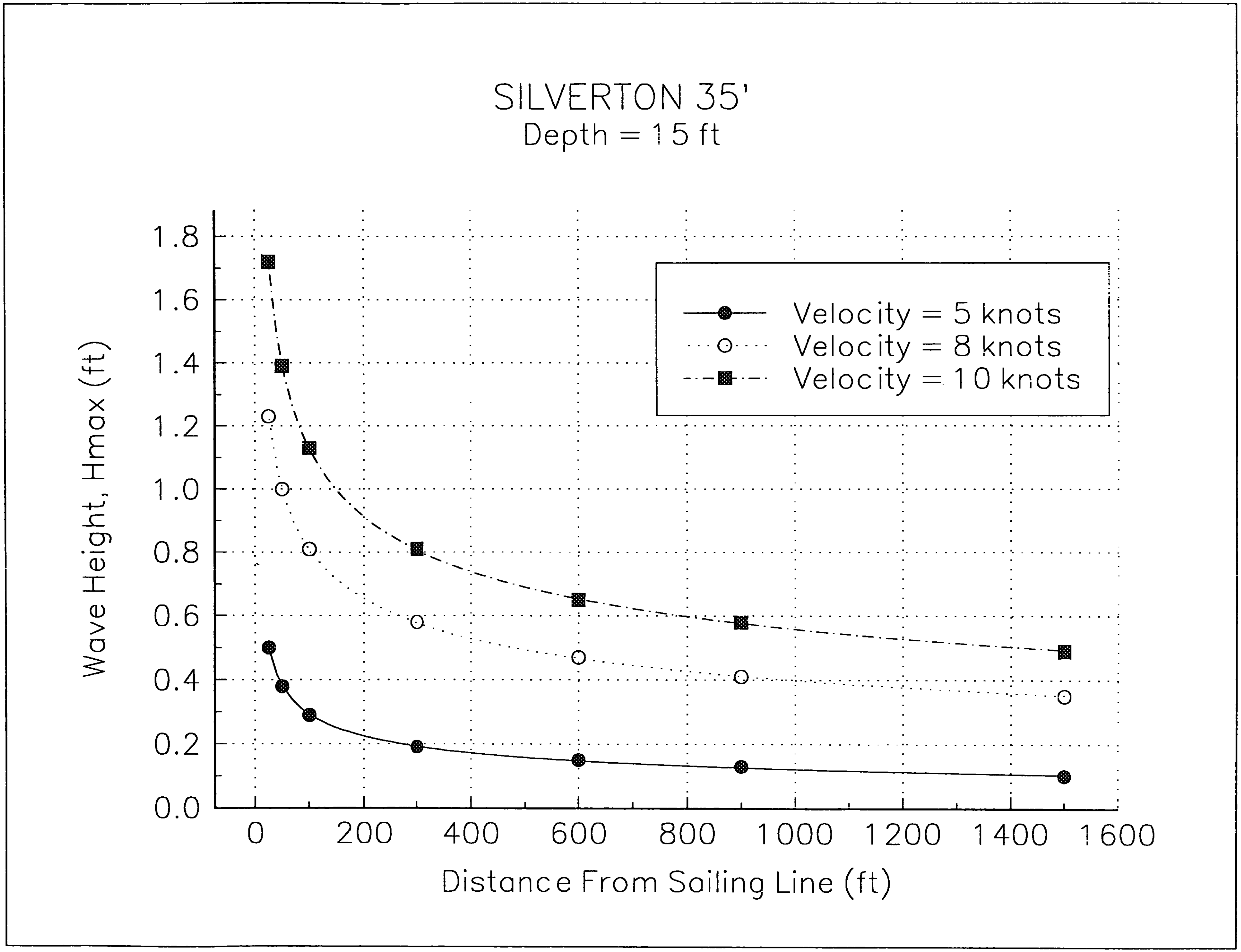

CHAPPARAL 29'
Depth = 8 ft
Velocity = 5 knots
Velocity = 8 knots
Wave Height, Hmax (ft)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)



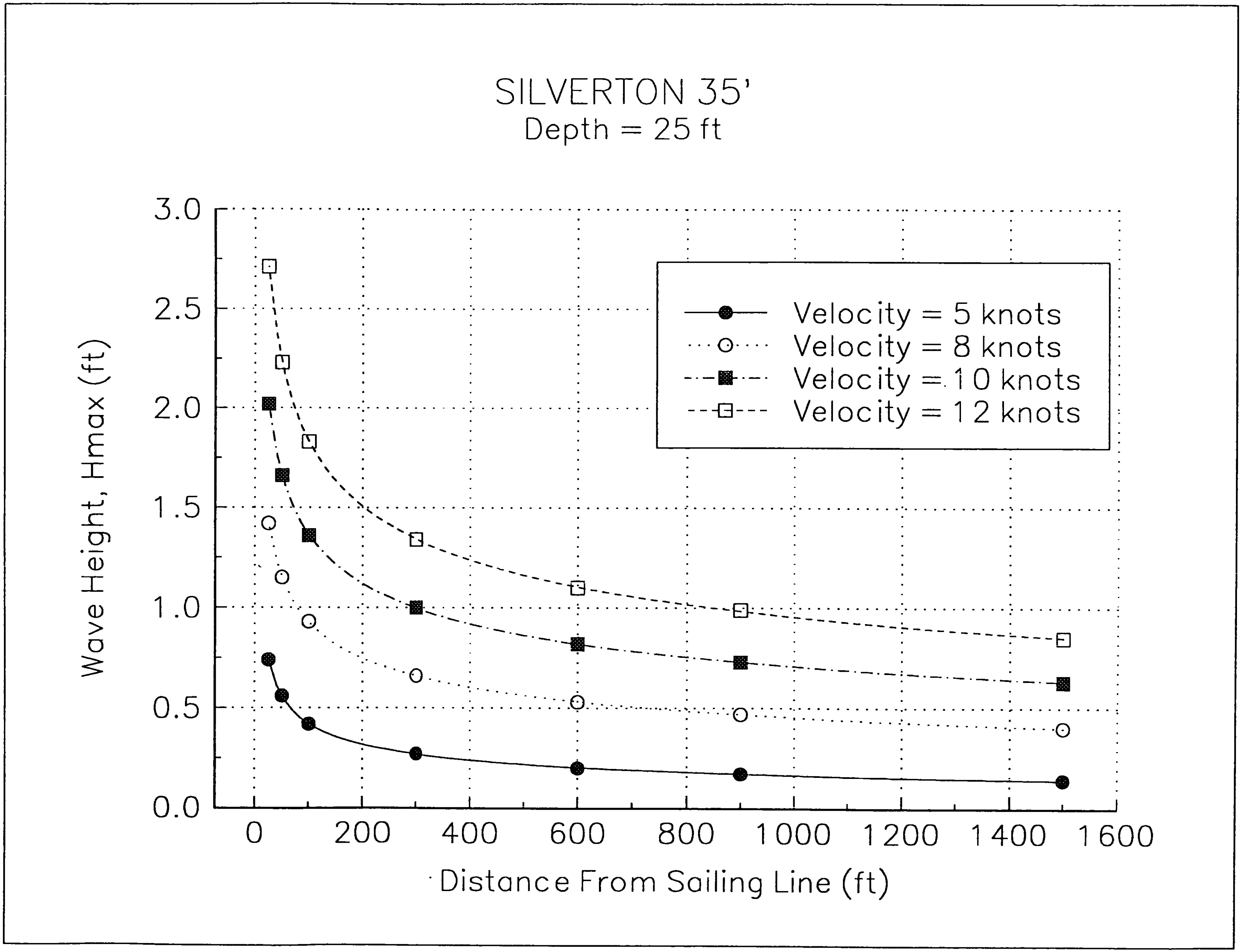
CHAPPARAL 29'
Depth = 15 ft
Wave Height, Hmax (ft)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots

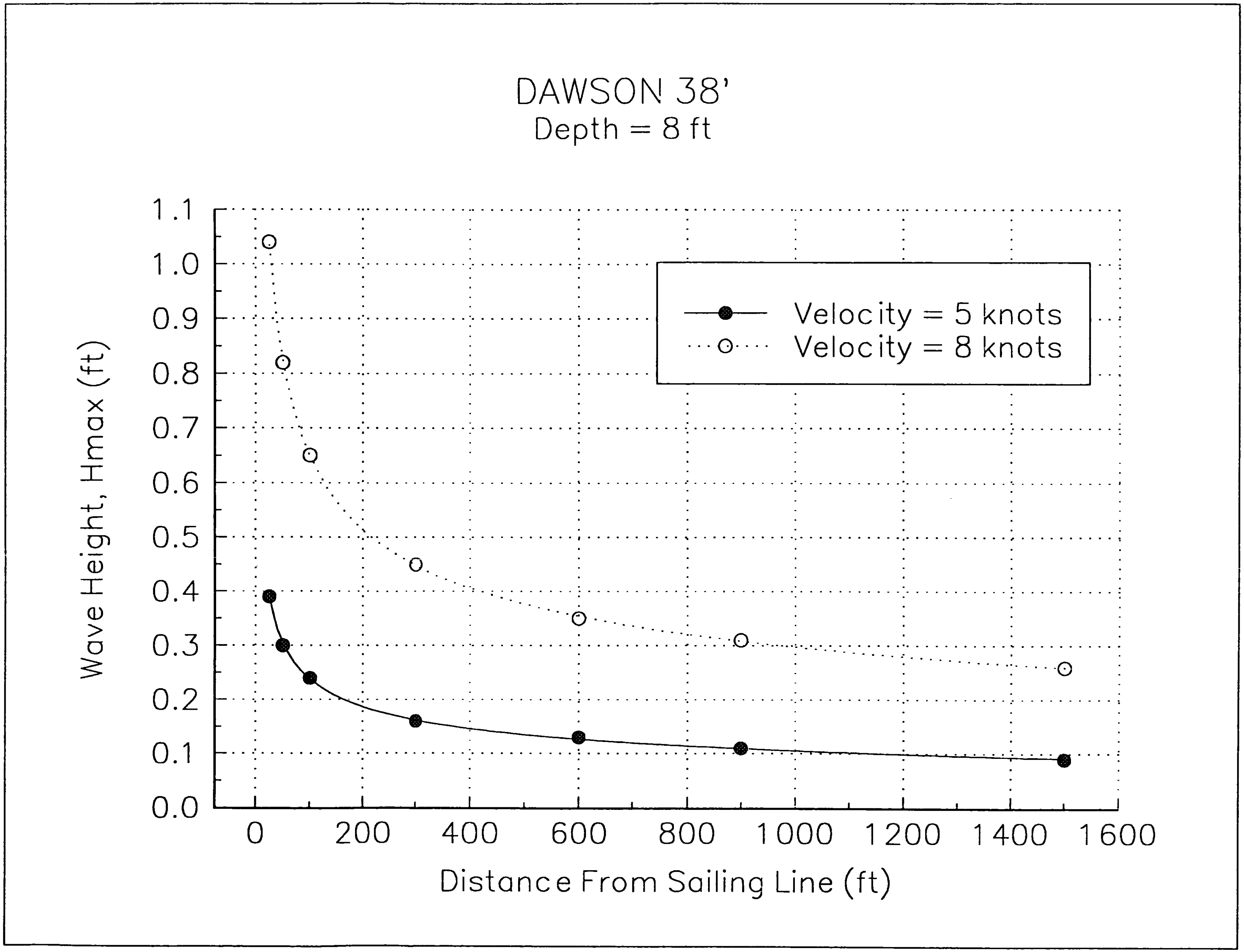

CHAPPARAL 29'
Depth = 25 ft
Wave Height, Hmax (ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots
Velocity = 12 knots

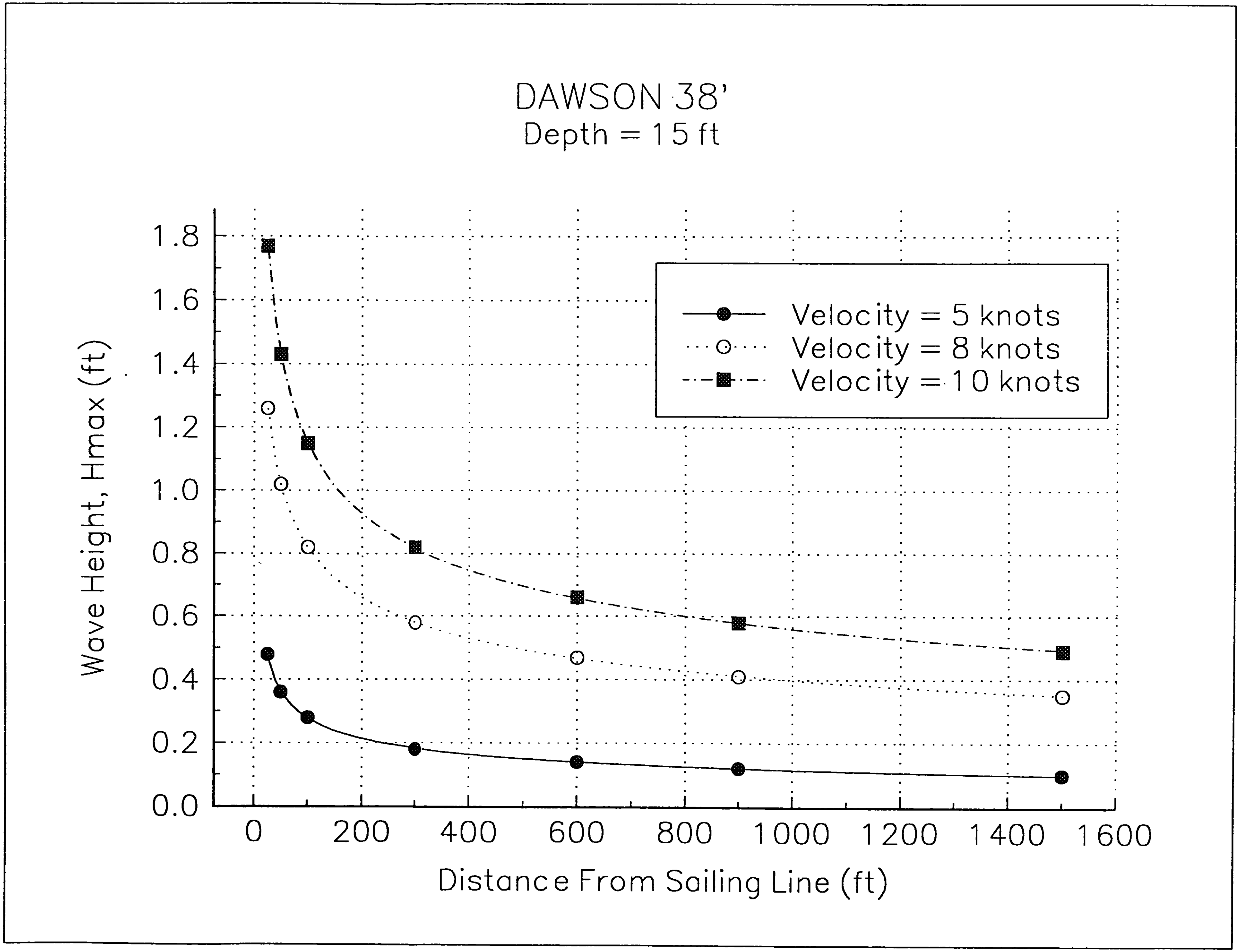

SILVERTON 35'
Depth = 8 ft
Velocity = 5 knots
Velocity = 8 knots
Wave Height, Hmax (ft)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)

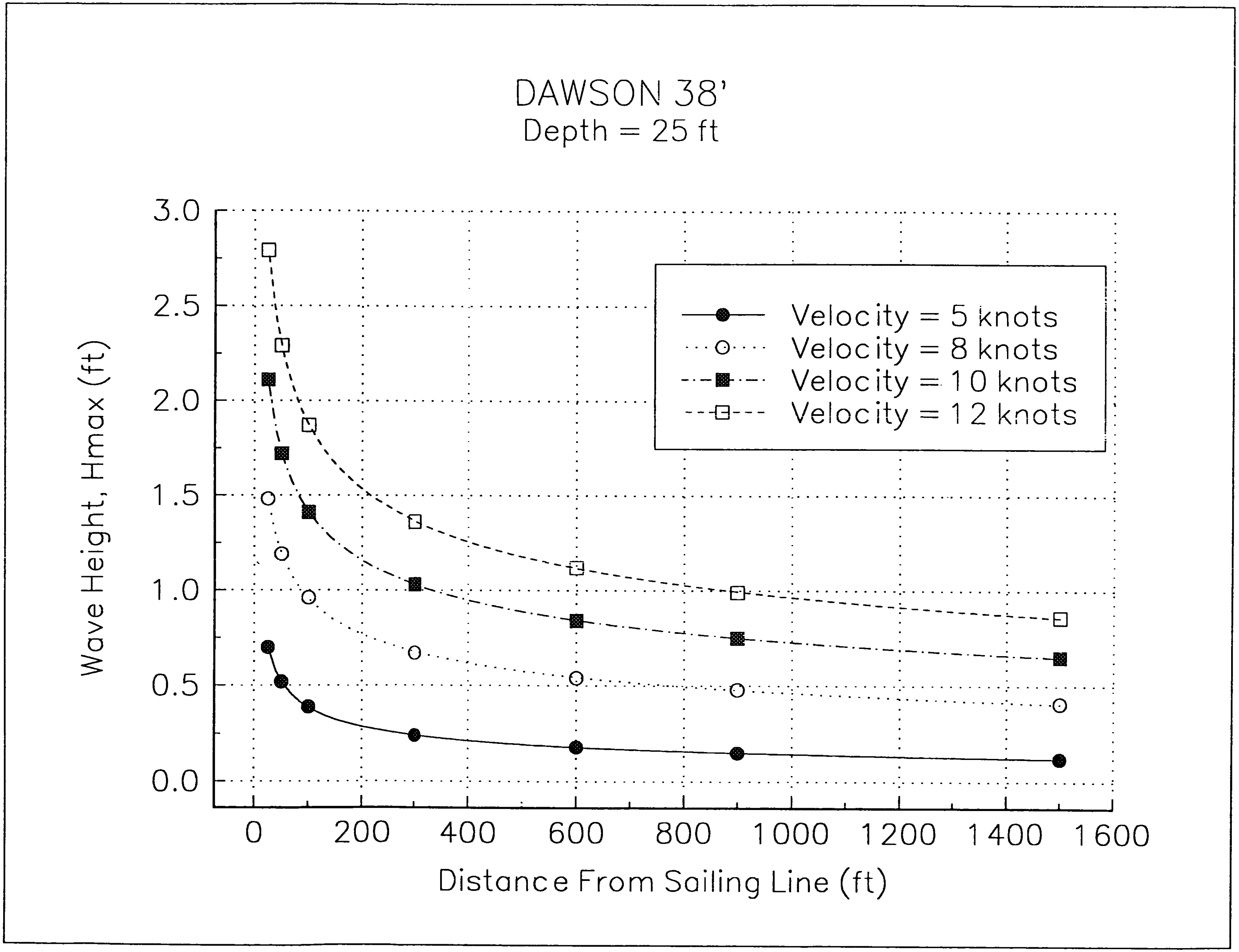


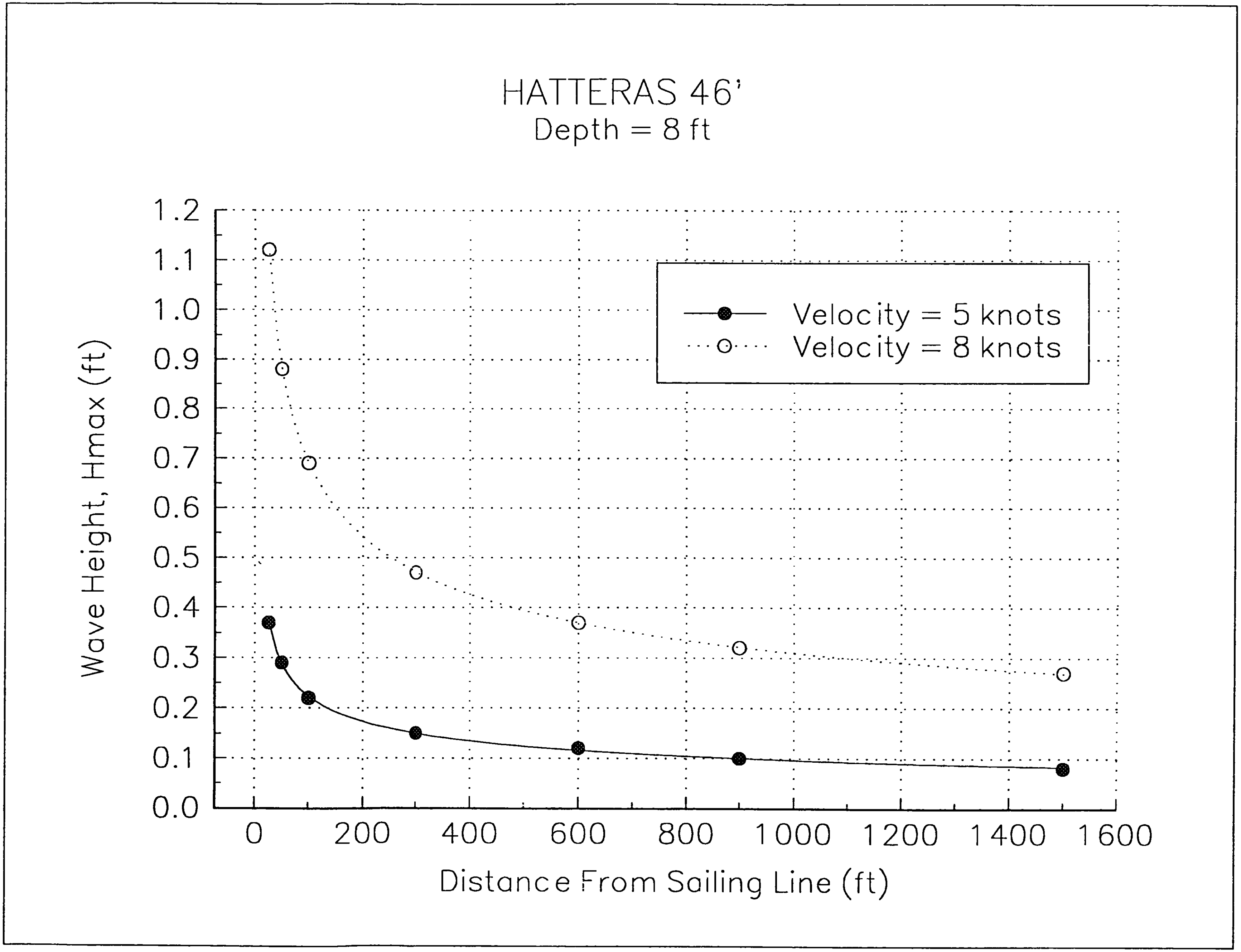
SILVERTON 35'
Depth = 15 ft
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots
Wave Height, Hmax (ft)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)

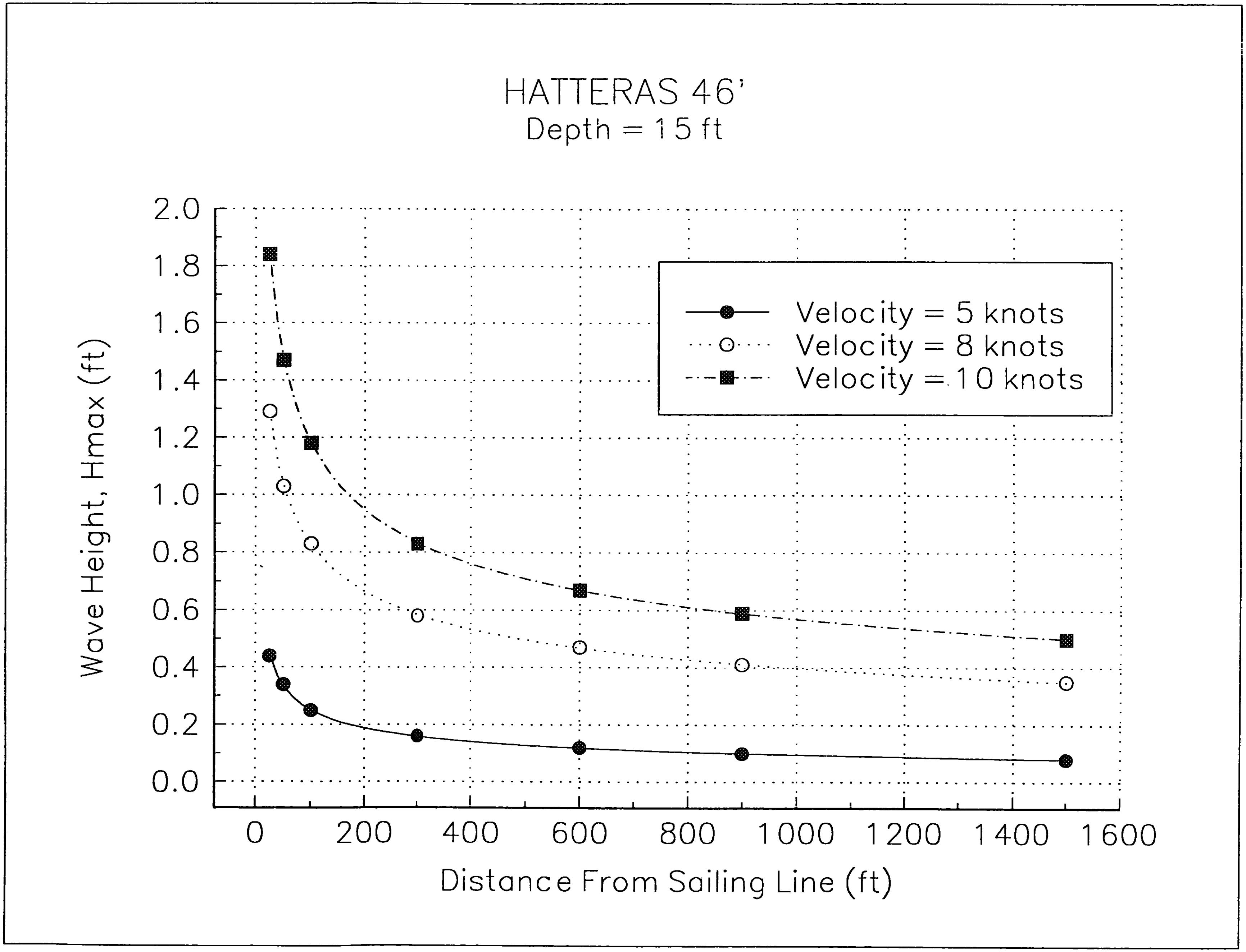

SILVERTON 35'
Depth = 25 ft
Wave Height, Hmax (ft)
Distance From Sailing Line (ft)
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots
Velocity = 12 knots
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
200
400
600
800
1000
1200
1400
1600

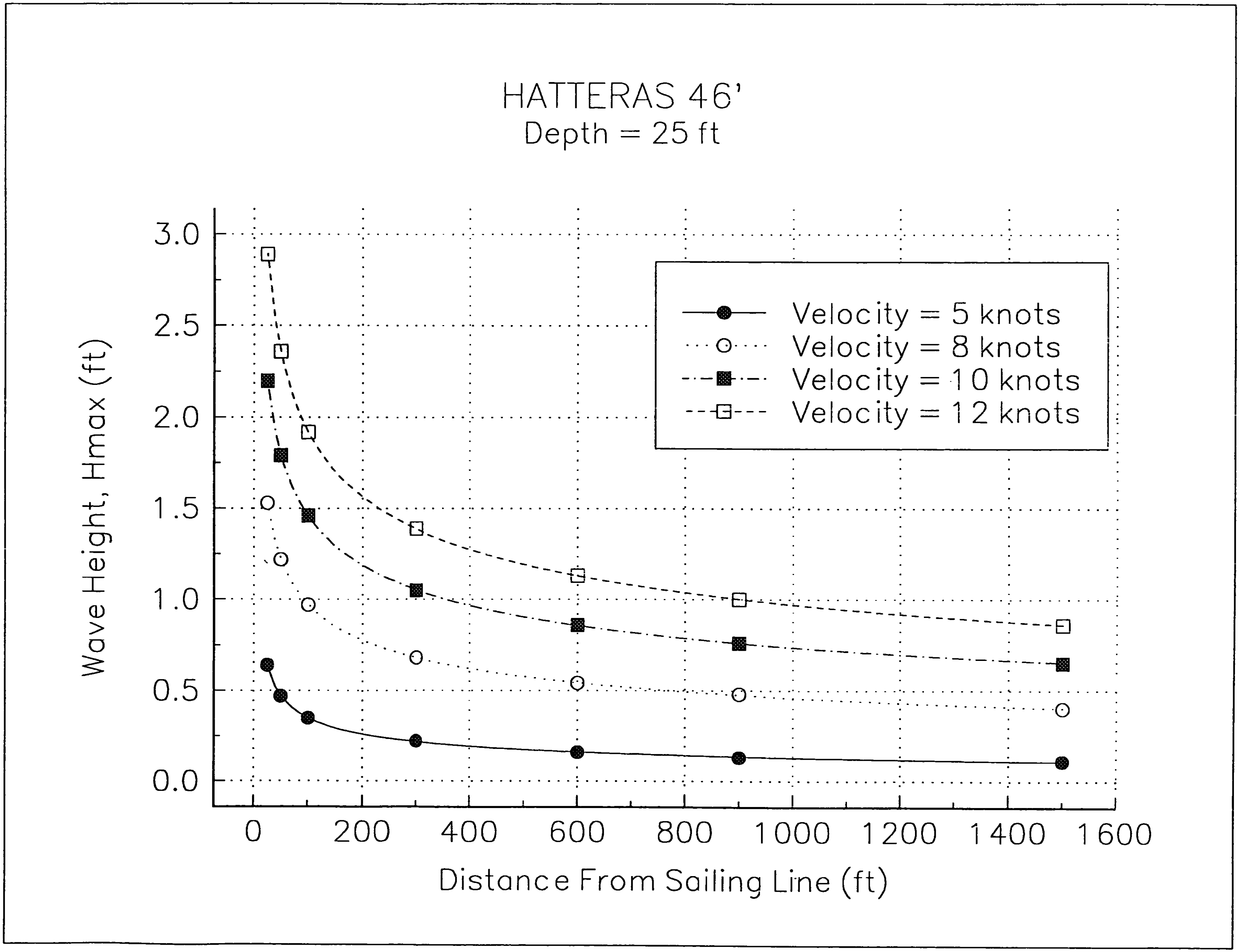

DAWSON 38'
Depth = 8 ft
Wave Height, Hmax (ft)
Distance From Sailing Line (ft)
Velocity = 5 knots
Velocity = 8 knots
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
200
400
600
800
1000
1200
1400
1600

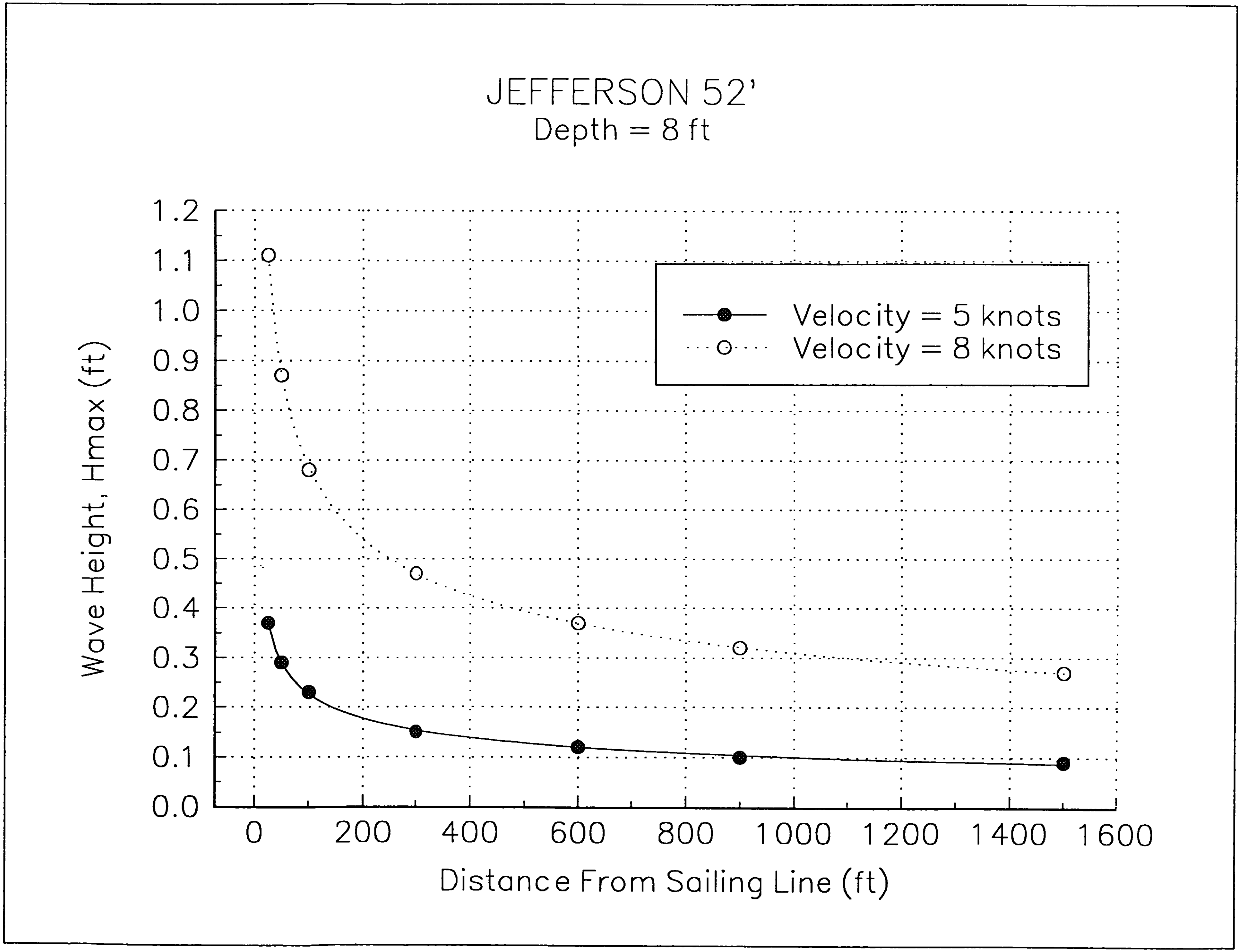

DAWSON 38'
Depth = 15 ft
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots
Wave Height, Hmax (ft)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)

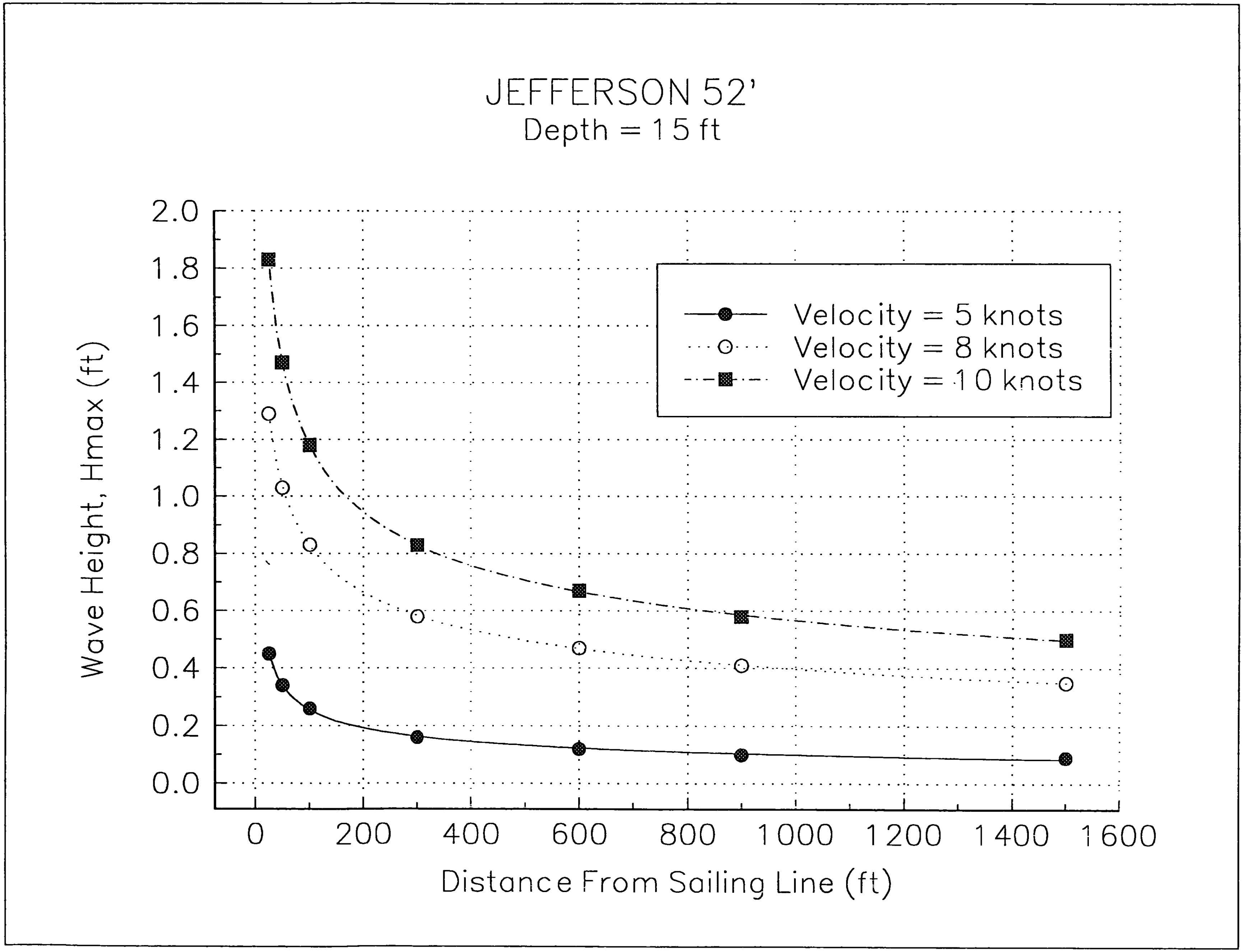

DAWSON 38'
Depth = 25 ft
Wave Height, Hmax (ft)
Distance From Sailing Line (ft)
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots
Velocity = 12 knots
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
200
400
600
800
1000
1200
1400
1600

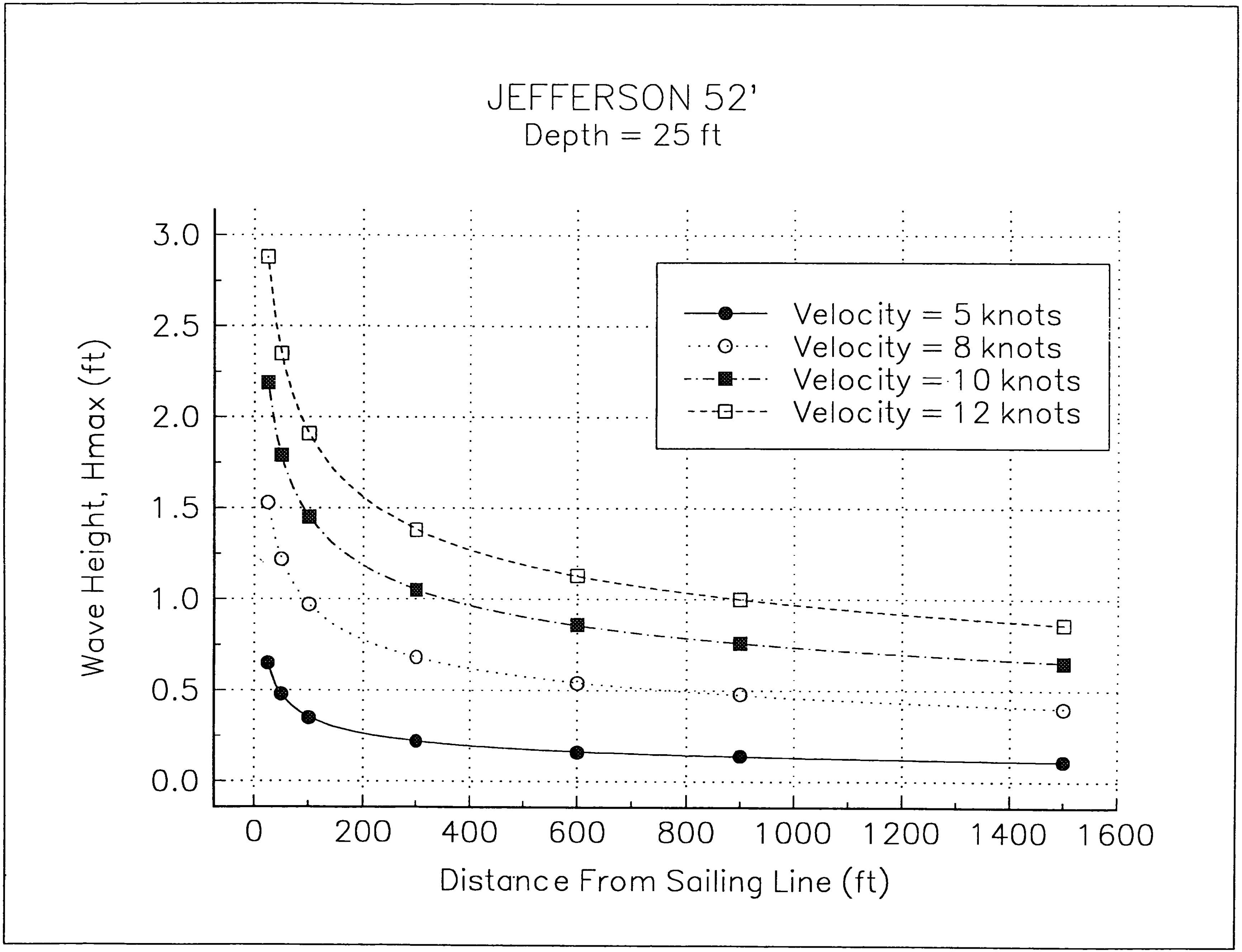

HATTERAS 46'
Depth = 8 ft
Wave Height, Hmax (ft)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)
Velocity = 5 knots
Velocity = 8 knots


HATTERAS 46'
Depth = 15 ft
Wave Height, Hmax (ft)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots


HATTERAS 46'
Depth = 25 ft
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots
Velocity = 12 knots
Wave Height, Hmax (ft)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)


JEFFERSON 52'
Depth = 8 ft
Velocity = 5 knots
Velocity = 8 knots
Wave Height, Hmax (ft)
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)


JEFFERSON 52'
Depth = 15 ft
Wave Height, Hmax (ft)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)


JEFFERSON 52'
Depth = 25 ft
Velocity = 5 knots
Velocity = 8 knots
Velocity = 10 knots
Velocity = 12 knots
Wave Height, Hmax (ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
200
400
600
800
1000
1200
1400
1600
Distance From Sailing Line (ft)

Appendix B

MARINE CONTRACTORS AND MATERIAL SUPPLIERS IN THE STATE OF MARYLAND

This appendix provides a list of marine contractors and material contractors doing business in the State of Maryland. The list was provided by the State of Maryland and is periodically updated.

MARINE CONTRACTORS
AND
MATERIAL SUPPLIERS
DIRECTORY

This directory is not intended to imply
Department of Natural Resources endorsement

Department of Natural Resources
Boating Administration
Shore Erosion Control
Tawes State Office Building
580 Taylor Avenue E-4
Annapolis, Maryland 21401
(410) 974-3727

3/17/93

MARINE CONTRACTORS

ALLEGHENY COUNTY

Mattingly Builders P.O. Box 248 Cumberland, Md 21502 Ms. Sheila S. Mattingly (301) 729-1500		

ANNE ARUNDEL COUNTY

A. H. Smith 1861 Crownsville Road Annapolis, Md 21401 Mr. Kurt Marley (410) 224-3356	Abuma Enterprises P.O. Box 213 Arnold, Md 21012 Mr. Maarten F. Maarschalkerweerd (410) 647-1939	Anderson Marine Construction, Inc. 313 South Drive Severna Park, Md 21146 Mr. G. L. Anderson (410) 647-5925
Aquatic Works, Inc. 313 South Drive Severna Park, MD 21146 Mr. Lenny Anderson (410) 647-5925	Arundel Structures P.O. Box 9745 Arnold, MD 21012 Mr. William Forthofer	Bayside Contractors 1254 Steamboat Road Shady Side, MD 20764 Mr. Gordan A. Crandall
C. A. Norris, Inc. P.O. Box 352 Pasadena, Md 21122 Mr. C. A. Norris (410) 255-3900	D-N-D Marine Construction 45 West Jones Station Road Severna Park, MD 21146 Mr. Harry Dewitt (410) 544-1285	Daniel M. Lerian Contracting 281 Beckworth Court Severna Park, Md 21146 Mr. Daniel M. Lerian (410) 544-0662
Davidsonville Sand & Gravel 5440 Greenock Road Lothian, MD 20820 Mr. H. D. Hunt (410) 261-7838	E. A. & J. O. Crandell, Inc. 733 Crandell Road West River, MD 20778 Mr. Charles A. Crandell (410) 269-5552, 867-0200	Empire Construction Company 700 Pittman Road Baltimore, MD 21226 Mr. Charles Jacobs (410) 636-6000
Ferguson Trenching Co., Inc. 123 Revell Highway Annapolis, MD 21401 Mr. Steve Ferguson (410) 757-5700	Francis R. Moreland 813 Main Street Galesville, MD 20765 Mr. Francis Moreland (410) 867-3325	George M. King Contractors, Inc. 1790 Severn Chapel Road Millersville, MD 21108 Mr. Robert Watson (410) 793-0760
Hardaway Constructors, Inc. P.O. Box 670 Severna Park, MD 21146 Mr. W. L. Womack (410) 647-7065	Heinsohn Contracting Company 958 Hilltop Road Arnold, MD 21012 Mr. Gerd Heinsohn (410) 974-4024	Hood Engrg. & Const. Co., Inc. P.O. Box 670 Severna Park, MD 21146 Mr. Donald E. Hood (410) 647-7389
Jaco Marine, Inc. 208 Oak Drive, Rt. 5 Pasadena, MD 21122 Mr. William Jahnigen (410) 255-6410	Jahnigen Marine Construction 757 N. Mesa Road Millersville, MD 21108 Mr. Timothy J. Jahnigen (410) 766-6572	John D. Sheetz, Inc. 829 Central Avenue Linthicum, MD 21090 Mr. John D. Sheetz (410) 789-1370
John H. Norris & Sons, Inc. 501 Palisades Blvd. Crownsville, MD 21032 Mr. Jack Norris, Jr. (410) 987-5646, 923-2348	K. D. Gross & Son Enterprises, Inc. 1480 Gross Circle Road Shady Side, MD 20764 (410) 867-0412	Kenster Corporation 621 Central Avenue Edgewater, MD 21037 Mr. William Brewster (410) 956-5390

Kiewit Eastern Co. 6797 Dorsey Road Baltimore, MD 21227-6206 Mr. Jack Frakes (301) 796-8311	L & W Marine Construction 719 Cottage Drive Arnold, MD 21012 Mr. Fred Wagner (410) 647-0455	Lerian-Bradbury, Inc. 281 Beckworth Court Severna Park, MD 21146 Mr. Daniel M. Lerian (410) 647-4444 & 544-3462/0662
McLean Contracting Company 6700 Curtis Court Glen Burnie, MD 21061 Mr. Richard F. Hoffman (410) 553-6700	Mohawk Contracting Co., Inc. 5500 Belle Grove Road Baltimore, MD 21225 Mr. Joseph Burton (410) 789-0497	Pile Drivers, Inc. 829 Central Avenue Linthicum, MD 21090 Mr. George J. McClure, Jr. (410) 789-1370
Pioneer Contracting 1331 Waterbury Road Crownsville, MD 21032 Mr. B. B. Patel	Powell Industries, Inc. P.O. Box 207 Severna Park, MD 21146 Mr. Wilham Powell (410) 647-8493	R. L. Geisler Marine Maint. Co. 9 Willow Street Annapolis, MD 21401 Mr. R. L. Geisler (410) 266-3965
Ray Sears & Son, Inc. 2387 Rutland Road Gambrills, MD 21054 Mr. Ray Sears (410) 261-6445, 721-0818	Sansbury Bulkhead & Pier 109 Lee Drive Annapolis, MD 21403 Mr. Samuel Sansbury (410) 268-4649	Skinner, Logsden Const. & Equip. P.O. Box 782 Glen Burnie, MD 21061 Mr. Tom Skinner (410) 551-6464
Smith Brothers, Inc. 4702 Woodfield Road Galesville, MD 20765 Mr. Kenneth W. Smith (301) 867-1818	Statewide Marine Const. Co. 1105 River Bay Road Annapolis, MD 21401 (410) 757-4405	Stocketts Excavating & Hauling 5262 Solomons Island Road Lothian, MD 20711-9702 Mr. David C. Stockett (301) 261-5811
Subterranean Construction Co., Inc. 1362 Marlboro Road Lothian, MD 20820 Mr. William H. Brown (301) 627-8445	Tidewater Marine Const. Co., Inc. 8440 Geneva Road Pasadena, MD 21122 Mr. Charles Barton (410) 255-5450	Ventura Co., Inc. 1761 Severn Chapel Road Crownsville, MD 21032 Mr. Kishor Pancholi (410) 721-9314
Walsh & Son, Inc. 1045 Broadview Drive Annapolis, MD 21401 Mr. Burt Walsh (410) 974-4201	Wrangler Construction Co. 501 Ardmore Drive, Box 120 Linthicum, Maryland 21090 Mr. Frank Vavra (410) 859-3232	The Wexford Construction Corp. P.O. Box 29 Pasadena, MD 21122 Mr. John Harms, III (410) 535-0648
Bay West Contractors 712 202nd Street Pasadena, MD 21122 Mr. Dennis Plummer (410) 255-7484		

BALTIMORE COUNTY/BALTIMORE CITY

Allied Contractors, Inc. 204 E. Preston Street Baltimore, MD 21202 Mr. Bill Cragg (410) 539-6727	Alpha Contracting Co. 4006 Eldorado Avenue Baltimore, MD 21215 Mr. Anthony Bates (410) 291-0808	Better Buildings, Inc. 625 South Smallwood Street Baltimore, MD 21223 Mr. J. E. Cilumbrello (410) 945-7733
Cotten Construction Co. P.O. Box 4862 Baltimore, MD 21211 Mr. Cusic Q. Cotten (410) 889-4791	Corman Construction, Inc. 1334 Sulpher Spring Road Baltimore, MD 21227 Mr. William O. Palmer (410) 621-1225	Crest Contracting Co., Inc. 10117 York Road, P.O. Box 206 Cockeysville, MD 21030 Mr. W. Ralph Wisner (410) 666-0900
A-J Marine, Inc. 6135 Regent Park Road Baltimore, MD 21228 Mr. Pateris (410) 744-5236	Drumwood Corporation 8617 Chestnut Oak Road Baltimore, MD 21234 Mr. John W. Treadwell (410) 661-8336	Eastern Pile Driving 612 Back River Neck Road Baltimore, MD 21221 Mr. Ward Holden (410) 391-1654
Ehrhardt & May, Inc. 5717 Harford Road Baltimore, MD 21214 Mr. Ernest Emerson (410) 687-1284, 687-6484	Emerson & Brown, Inc. 2228 Monacacy Road Baltimore, MD 21221 Mr. Ernest Emerson (410) 687-1284, 687-6480	P. Flanigan & Sons, Inc. 2444 Loch Raven Road Baltimore, MD 21218 Mr. Pierce Flanigan, III (410) 467-5900
Melvin C. Benhoff & Sons, Inc. 4216 Old North Point Road Baltimore, MD 21222 Mr. Daniel Benhoff (410) 477-5650	William A. Harting & Son, Inc. 2930 Hammonds Ferry Road Baltimore, MD 21227 Mr. Claude Vanoy (410) 247-0220	Iacoboni Site Specialists, Inc. P.O. Box 72550 Baltimore, MD 21237 Mr. Thomas J. Iacoboni (410) 686-2100
Martin G. Imbach, Inc. 6121 Pennington Avenue Baltimore, MD 21226 Mr. F. X. McGeady (410) 355-6121	Interstate-Feezer Joint Venture P.O. Box 5826 Pikesville, MD 21208 Mr. John F. Feezer III (410) 247-5411	Kibler Excavating, Bldg., Eng 3648 Washington, Blvd. Baltimore, Maryland 21227 Mr. Matt Kibler (410) 242-3337
C. J. Langenfelder & Son, Inc. 8427 Pulaski, P.O. Box 9606 Baltimore, MD 21237 Mr. William Hazlehurst (410) 682-2000	Lee Foundation Co., Inc. 8210 Harford Road Baltimore, MD 21234 Mr. Edward E. Lipinski, Jr. (410) 661-1616	Macfarlane Construction, Ltd. 215 Cockeysville Road Cockeysvile, MD 21030 Mr. Thomas Macfarlane (410) 667-1370
Fred J. Miller, Inc. 7601 Bradshaw Road Kingsville, MD 21087 Mr. Fred J. Miller (410) 592-6575, 592-6516	P. & J. Contracting Co., Inc. 5305 Eleanora Avenue Baltimore, MD 21215 Mr. Pless Jones (410) 358-3373	General Paving & Contracting, Inc. 20 Falls Road Baltimore, MD 21209 Mr. John Treadwell (410) 825-3397
Potts & Callahan, Inc. 500 W. 29th Street Baltimore, MD 21211 Mr. L. N. Phillipy (410) 235-9400	Ratrie, Robbins & Schweizer, Inc. 2313 St. Paul Street Baltimore, MD 21218 (410) 338-4200	Rehbein & Son, Inc. Box 109 Chase, MD 21027 Mr. Milton A. Rehbein, Jr. (410) 335-4037, 335-3575

Rocchi Construction Corp. 10720 Beaver Dam Road Cockeysville, MD 21030 Mr. James R. Rigger (410) 666-3320	Louis F. Soul Co., Inc. 6918 University Drive Baltimore, MD 21220 Mr. Louis F. Soul (410) 288-3669	Structural Preservation Systems 2116 Monumental Road Baltimore, MD 21227 Mr. Peter Emmons (410) 247-1800
Kodeck Construction Co., Inc. 3600 Labyrinth Road Baltimore, MD 21215 Mr. Kolman Kodeck (410) 358-5735	Joseph L. Werner, Inc. P.O. Box 18434 Baltimore, MD 21237 Mr. Joseph L. Werner, Sr. (410) 483-1500	J. L. Stoots Marine Contractors 4408 Webster Lapidum Road Havre De Grace, MD 21078-1338 Mr. James L. Stoots (410) 337-7853
Warwick Supply & Equipment, Co. 206 E. Preston Street Baltimore, MD 21202 Ms. Brigid Wist (410) 837-8440		

CALVERT COUNTY

Allied Marine Systems Co. Box 235 Solomons, MD 20688 R. Gibbons (301) 326-3367, 326-3459	Calvert Pile Driving, Inc. P.O. Box 30 St. Leonard, MD 20685 Mr. Davis S. Gray (301) 586-1058, 855-1707	G & S Marine Construction P.O. Box 30 St. Leonard, MD 20865 Mr. Davis S. Gray (301) 586-1058
Thomas L. Hance, Inc. Box 50 Prince Frederick, MD 20678 Mr. Thomas L. Hance, Jr. (301) 586-0383, 586-0404	Humphreys Construction Corp. SR 2, Box 37-Y St. Leonard, MD 20685 Mr. Michael Burns (301) 586-0311	

CAROLINE COUNTY

Kibler Brothers Rt. 1, Box 321 Greensboro, MD 21639 Mr. Lester Kibler (301) 482-8955		

CARROLL COUNTY

G. V. Hooper, Inc. 18 Charmil Drive Manchester, MD 21102 Mr. George Hooper (301) 239-8836	Kibler Construction Co., Inc. 6206 Sykesville Road Sykesville, MD 21784 Mr. James Kibler (301) 795-2365	C & C Inc. 6013 Old Washington Road Sykesville, MD 21784 Mr. Robert M. Gunning, Jr. (301) 795-0374, 440-0884

CECIL COUNTY

Cecil Construction Corp. P.O. Box 1177 Elkton, MD 21921 Mr. Frank Bush	Edward P. Howell, Inc. 1601 W. Pulaski Highway Elkton, MD 21921 Mr. Edward Howell (301) 287-5353	Johnston's Construction Co., Inc. 316 East Main Street Rising Sun, Maryland 21911 Mr. Warren C. Eastburn (301) 658-6525
Ocean Salvage, Inc. 366 Broad St. Perryville, MD 21903 Mr. Robert P. Hooper (301) 642-2447	PVC, Inc. 947 Blue Ball Road Elkton, MD 21921 Mr. Fred Herron (301) 392-4842	Tide Water Pile Driving, Co. Cecilton, MD 21913 Mr. Maurice O. Preston (301) 275-8622
Coates Construction Corp. P.O. Box 299 Warwick, MD 21912 Mr. Walt Drummon, Jr. (301) 755-6015		

CHARLES COUNTY

C. W. Stack & Associates, Inc. Route 1, Box 325 Nanjemoy, MD 20662 Mr. C. W. Stack (301) 246-4135		

DORCHESTER COUNTY

Burton Hastings, Inc. Route 2, Box 212 Cambridge, MD 21613 Mr. Burton Hastings (301) 228-1980	Trego Construction, Inc. 906 Talisman Lane Cambridge, MD 21613 Mr. Read Trego (301) 228-4926	Kool Ice & Seafood Co. 110 Washington St. Cambridge, MD 21613 Mr. Dave Nickerson (301) 228-2300
Erik K. Straub, Inc. 306 Trenton St. Cambridge, MD 21613 Mr. Erik K. Straub (301) 228-0200	Roland E. Trego & Sons, Inc. Box 38 Secretary, MD 21664 Mr. Thomas W. Trego (301) 943-3284	Coastal Dock & Marine Const. Co. 16 Washington St. P.O. Box 977 Cambridge, Maryland 21613 (301) 228-8100

HARFORD COUNTY

Bowerman Marina 11008 Bowerman Road White Marsh, MD 21162 Mr. George S. Bowerman, Jr. (301) 335-5636	Chesapeake Bay Construction 759 Shore Drive Joppa, MD 21085 Mr. Joel Abramson (301) 679-6945	Fred L. Hawkins, Co., Inc. 1315 Pulaski Highway Havre De Grace, MD 21078 Mr. Fred Hawkins (301) 939-5100, 575-7015
Har-Ce Construction, Inc. 403 N. Adams Street Havre De Grace, MD 21078 Mr. Robert Wood (301) 939-2837, 575-6711	J. M. Comer Construction, Inc. 2100 Slade Lane Forest Hill, MD 21050 Mr. Leslie P. Cox (301) 879-6094	T. C. Simmons, Inc. 2011 Bel Air Road Fallston, MD 21047 Mr. Talmadge E. Simmons (301) 877-8156

Ward Contracting P.O. Box 196 Forest Hill, MD 21050 Mr. Charles Ward (301) 879-1967, 838-6996		

HOWARD COUNTY

Cherry Hill Sand & Gravel Co. 8170 Mission Road Jessup, MD 20794 Mr. James A. Openshaw, Jr. (301) 953-2700, 799-3577	D. M. & S., Inc. 11223 Albeth Road Marriottsville, MD 21104 Mr. Gene Asher (301) 442-1577	Interstate-Feezer Joint Venture P.O. Box 5826 Pikesville, MD 21208 Mr. John F. Feezer, III (301) 796-3155
Parrott Equipment Co. 6421 Louden Avenue Elkridge, MD 21227 Mr. Albert G. Parratt (301) 796-2480, (202) 621-1030	Pickens & Sons, Inc. 6510 Haviland Mill Road Clarksville, MD 21029 Mr. Rick Casciloi (301) 854-2066	

KENT COUNTY

Bay Marine Construction, Inc. 800 High Street Chestertown, MD 21620 Mr. Bob Wilkie (301) 778-2000, Ext. 241	David A. Bramble, Inc. P.O. Box 419 Chestertown, MD 21620 Mr. David A. Bramble (301) 778-3023	Chesapeake Bay Marine Const. Co. Route 1, Box 330-A Rock Hall, MD 21661 Mr. George E. Elbourn (301) 639-7959
Roy P. Elbourn Route 1, Box 285 Rock Hall, Maryland 21661 (301) 639-7170	Lindstrom Excavating Contractors Box 69, Route #1 Worton, MD 21678 Mr. Duane Lindstrom (301) 778-6344	Rolcom Pile Driving Box 198 Rock Hall, MD 21661 Mr. Marijoan Linder (301) 639-7535
William A. Simpler, Jr. Route 1, Box 241 Millington, MD 21651 Mr. William A. Simpler, Jr. (301) 928-3185	Williams Brothers Box 28 Rock Hall, MD 21661 Mr. Joseph B. Williams (301) 639-2241	

MONTGOMERY COUNTY

Deneau Construction, Inc. 16634 Oakmont Avenue Gaithersburg, MD 20877 (301) 840-1007	First Cambridge Corp. One Central Plaza, Suite 1208 11300 Rockville Pike Rocksville, MD 20852 Ms. Charlotte Lazrus (301) 984-7800	A. E. Froemel Associates P.O. Box 593 Olney, MD 20832 Mr. A. E. Froemel (301) 774-2858
F. E. Gregory & Sons, Inc. 8135 Snouffer School Road Gaithersburg, MD 20879 Mr. Chas. Judy (301) 948-2888	Commercial Marine Services, Inc. P.O. Box 10811 Rockville, MD 20849 Mr. Jeff Cohen (301) 258-5092	Coates Construction Corporation 6701 Rockledge Drive, Suite 750 Bethesda, MD 20871 Mr. Walt Drummond, Jr. (301) 530-4400

Kora and Williams Corporation 8412 Georgia Avenue Silver Spring, MD 20910 Mr. Ira Steinberg (301) 770-6132	J. Palmeiro Construction, Inc. P.O. Box 30652 Bethesda, MD 20814 Mrs. Marsh (301) 652-6598	Samuel C. Rosner Gen. Contractor 12409 Flack Street Wheaton, MD 20906 Mr. Sam Rosner (301) 942-3620
Stauffer Construction Co., Inc. 11141 Georgia Avenue, Suite 412 Wheaton, MD 20902 Mr. Bruce Stauffer (301) 949-1600	T. J. Company, Inc. P.O. Box 4234 Silver Spring, MD 20904 Mr. Thomas M. Lanigan, Jr. (301) 384-9834	Darwin Construction Co., Inc. 8001 Wisconsin Avenue Betheseda, MD 20314 Mr. Lester J. Robinson (301) 986-1480

PRINCE GEORGE'S COUNTY

Brandywine Sand & Gravel Co. 5800 Sheriff Road Fairmount Heights, MD 20027 Mr. John W. Spivey (301) 925-8100	John Driggs Company, Inc. 8622 Ashwood Drive Capitol Heights, MD 20027 Mr. Ralph Goldin (301) 350-4000	Gebhardt, Inc. 7708 Alexander Ferry Road Clinton, MD 20735-0026 Mr. Robert W. Wright
Excavation-Construction, Inc. 2800 52nd Ave. P.O. Box 468 Bladensburg, MD 20710 Mr. Dewey East (301) 779-4040	Flippo Construction Co. 3820 Penn-Belt Place Forestville, MD 20747 Mr. Robert E. Berngartt (301) 967-6800	G. W. Mechanical Contrs., Inc. 5007 Suitland Road Suitland, MD 20746 Mr. Alfred C. Goodspeed (301) 420-1424
Tri-County Industries, Inc. 7407 Farmcrest Drive New Carrollton, MD 20784 Mr. Glen Selzer (301) 441-8157	R. Marinucci & Sons, Inc. P.O. Box 137 11609 Edmondston Road Beltsville, MD 20705 Mr. Michael Marinucci (301) 595-5806	Pagliaro Bros. Stone Co., Inc. 9310 D'Arcy Road Upper Marlboro, MD 20772 Mr. Joe Pagliaro (301) 350-8600
Ventresca & Sons, Inc. 5101 Sunnyside Ave. College Park, Maryland 20740 Mr. Gerald A. Ventresca (301) 474-2171	Dewey East Excavating Co., Inc. P.O. Box 600 Bladensburg, MD 20710 Mr. Ken Richardson (301) 454-8166	

QUEEN ANNE'S COUNTY

Bloomingdale Const. Co., Inc. P.O. Box 15 Main Street Queenstown, MD 21658 Mr. W. Edwin Cole (301) 827-8734, 827-8984	Michael Davidson Excavating Route 1, Box 50D Centreville, MD 21617 Mr. Michael P. Davidson (301) 758-2618	Off Shore Marine Construction 102 Chesapeake Estates Drive Stevensville, MD 21666 Mr. George Klapka (301) 643-2711
Dissen & Juhn Corporation Box 517 Route 18 Grasonville, MD 21638 Mr. Mark Dissen		

ST. MARY'S COUNTY

B. F. Asher P.O. Box 154 Mechanicsville, MD 20659 Mr. B. F. Asher, Jr. (301) 884-5252	B & W Pile Driving Co. Box 81 Lexington, Park, MD 20634 (301) 872-5044	Jimmy Bean Excavating, Inc. Route 2, Box 16 Valley Lee, MD 20692 Mr. James Bean (301) 994-2011, 994-1158
Colliflower & Peterson, Inc. Box 35 Callaway MD 20620 Mr. Stephen Peterson (301) 994-2824	Insley Construction Co. Route 1, Box 52 Hollywood, MD 20636 Mr. Donald Insley (301) 373-2515	Elva Mattingly Route 1, Box 86-C Leonardtown, MD 20650 Mrs. Elva Mattingly (301) 475-2421
Randy's Pier & Seawall RFD 1 Box 144-1 Leonardtown, MD 20650 Mr. Randy Beckwith		

SOMERSET COUNTY

George L. Custis & Son Box 11 Marion, MD 21838 Mr. George L. Custis (301) 623-8134		

TALBOT COUNTY

Bailey Marine Construction, Inc. Route 1, Box 361 Easton, MD 21601 Mr. J. Lee Bailey (301) 822-2205	J. Marion Bryan & Sons, Inc. Drawer X St. Michaels, MD 21663 Mr. William O. Bryan (301) 745-5075	E. S. Diefenderfer, Sr. Route 2, Box 141 Trappe, MD 21673 Mr. E. S. Diefenderfer, Sr. (301) 476-3386
R. L. Ewing, Jr. Gen. Const. Route 2, Box 28 Easton, MD 21601 Mr. R. L. Ewing (301) 822-0272	Harper & Sons, Inc. P.O. Box 158 Queen Anne, MD 21657 Mr. Stephen H. Harper (301) 820-2192	Mansfield & Sons, Inc. Route 1, Box 66A Cordova, MD 21625 Mr. Joseph S. Mansfield, Sr. (301) 822-4646, 820-2031
William M. Ozman P.O. Box 142 Trappe, MD 21673 (301) 822-2994	Melvin C. Benhoff & Sons, Inc. Eastern Shore Division Route 3, Box 470P Easton, MD 21601 Mr. Daniel J. Benhoff (301)	Norris E. Taylor Contractors, Inc. 209 North Route 50 Easton, MD 21601 Mr. Norris E. Taylor (301) 822-2050
Tyler Contracting Company P.O. Box 539 St. Michaels, MD 21663 Mr. Walter R. Tyler, Jr. (301) 745-2323	Scott J. Wallace Const. Co., Inc. Route 1, Box 100 Cumberland Farm Royal Oak, MD 21662 Mr. Scott Wallace (301) 745-9313	Weems Brothers, Inc. Route 2, Box 161 Trappe, MD 21673 Mr. Robert Weems (301) 822-0510

WASHINGTON COUNTY

Plummer Construction, Inc. 81 Edgewood Dr., P.O. Box 1159 Hagerstown, MD 21740 Mr. W. Louis Plummer, Jr. (301) 739-1986		

WICOMICO COUNTY

Dolbey Marine Construction 840 W. Isabella Street P.O. Box 1797 Salisbury, MD 21801 Mr. Charles Dolbey	Fred M. Gardner, Gen. Contractor 400 Atlantic Avenue Salisbury, MD 21801 Mr. Fred M. Gardner (301) 742-7365	Wicomico Construction Co., Inc. P.O. Box 1613 Salisbury, MD 21801 Mr. Joseph Karpinski (301) 742-3500, 896-2900

WORCESTER COUNTY

Bayside Bulkheading, Inc. 103 Nancy Avenue Berlin, MD 21811 Mr. William Bunting (301) 641-0388	J. Bunting Marine Construction 504 Edgewater Ave. Ocean City, MD 21842 Mr. William Bunting (301) 289-1122, 289-9320	W. D. Lutch Construction, Inc. P.O. Box 544 Ocean City, MD 21842 Mr. William Lutch (301) 289-3528
Apple Marine Construction, Inc. P.O. Box 524 Ocean City, MD 21842 Mr. George Apple (301) 289-3443	M & M/Russell Construction P.O. box 126 Ocean City, MD 21842 Mr. Dennis C. Russell (301) 289-6991	

OUT OF STATE CONTRACTORS

DELAWARE

E. L. Batzel Company 4932 Old Capitol Trail Wilmington, DE 19808 Mr. Edgar L. Batzel (302) 998-3553	S. Batzel Company 4932 Old Capitol Trail Wilmington, DE 19808 Mr. Stephen Batzel (302) 998-3553	Cecil Construction Corp. P.O. Box 1177 New Castle, DE 19720 Mr. Frank Bush (302) 658-5024
The Centerville Co. Contractors P.O. Box 3631 Greenville, DE 19807 Mr. Don McDonald, Jr. (302) 656-8666	First States Enterprises, Inc. Eastern States Construction Services 702 1st State Blvd. Wilmington, DE 19804 Mr. Eugene M. Julian (302) 998-0683	George & Lynch, Inc. 113 West Sixth Street New Castle, DE 19720 Mr. Robert A. Appleby (302) 328-6275
Melvin L. Joseph Construction Co. RD #1, Box 218 Georgetown, DE 19947 Mr. G. Brinker (302) 856-7396	Kuhn Construction Company P.O. Box 141 Hockessin, Delaware 19707 Mr. William Kuhn, Jr. (302) 239-4344	R.A.M. Construction Co. RD #1, Box 479½ Frederica, DE 19946 Ms. Yvonne E. Mitten (302) 335-5130

W. P. Sharp & Sons, Inc. P.O. Box 223 Milton, DE 19968 Mr. W. P. Sharp, Sr. (302) 684-8508	Shelly's of Delaware, Inc. 610 W. 8th Street Wilmington, DE 19801 Mr. Rock Brown (302) 656-3337	Sun Marine Maintenance Co. Rt. 2, Box 212A Frankford, DE 19945 Mr. Michael Jahnigen (302) 539-6756
Teal Construction, Inc. P.O. Box 779 Dover, DE 19903 Mr. David Shevock (302) 674-4192	Valley Road Construction, Inc. P.O. Box 141 Hockessin, DE 19707 Ms. Helen M. Kuhn (302) 239-2331	Coastal Construction Co. P.O. Box 122 Greenwood, DE 19950 Kelly Nichols (302) 349-5059
Atlantic Sea-Con, Ltd. P.O. Box 112 801 East 6th Street New Castle, DE 19720 Mr. Charlie D'Agostino (302) 323-1340	Conn-E Construction Co. 1129A Brickyard Road Seaford, DE 19973 Ms. Connie F. Lewis (302) 629-9303	James Julian, Inc. 405 South DuPont Road Elsmere, Willmington, DE 19805 Mr. Michael DeStefano (302) 998-3391

MASSACHUSETTS

J. M. Cashman, Inc. P.O. Box 75 N. Weymouth, MA 02191 Mr. Jay M. Cashman (617) 337-1500		

NEW HAMPSHIRE

Folsom Marine Service Corp. P.O. Box 707 Ashland, NH 03217 Mr. Richard A. Folsom (603) 968-7997		

NEW JERSEY

Coastal Structures, Inc. 1101 Richmond Ave., Suite 103 Point Pleasant, NJ 08742 Mr. Gary J. McGeddy (201) 892-2991	Industrial Engineering Works P.O. Box 8008 Trenton, NJ 08650 (609) 586-5005	Joseph A. McCollum Co., Inc. P.O. Box 900 Marlton, NJ 08053 Mr. William Doran (609) 983-0550
W. H. Streit, Inc. 107 Drivers Lane Laurel Springs NJ 08021 Mr. Robert Regan	Paz Brothers, Inc. 103 Logan Lane, P.O. Box 517 Bridgeport, NJ 08014 Mr. John Paz (609) 467-0123, 467-0170	Raymond International, Inc. 6852 Westfield Avenue Pennsauken, NJ 08110 Mr. Joseph P. Welsh (609) 667-3323
Subaqueous Enterprises, Inc. RD #1, Box 396 Mays Landing, NJ 08330 MR. William A. Schwiers (609) 927-8084, 927-1230	John E. Taylor Construction Co. 42 Main Street Bridgeport, NJ 08014 Mr. Jack Taylor (609) 467-1392	Thomson's Trenching, Inc. 409 N. Railroad Avenue Rio Grand, NJ 08242 Mr. Robert Thomson (609) 886-8111

Walker Diving Contractors, Inc. 107 Drivers Lane Laurel Springs, NJ 08021 Mr. Harry J. Streit (609) 784-2208	Waterfront Corporation 800 Cooper Street Camden, NJ 08102 Ms. Cynthia A. Hudson (609) 342-6500	

NEW YORK

Coastal Dock Building Corp. 347 McConnell Avenue Bayport, NY 11705 Mr. John Snyder (516) 472-0001	Dissen & Juhn Corp. 3340 Canandaigua Road Macedon, NY 14502 Mr. Martin Juhn (315) 986-4416	

PENNSYLVANIA

Coatesville Contractors & Engrs. 1100 Bondsville Road Dowingtown, PA 19335 Mr. John J. Fallon (215) 384-2731	Allan a. Myers, Inc. P.O. Box 98 Worcester, PA 19490 Mr. Charles D. Lanan (215) 584-6020	G. A. & F. C. Wagman, Inc. 3290 Susquehanna Trail North York, PA 17405 Mr. Thomas E. Otto (717) 764-8521
L. B. Foster Company 7247 Tilghman St. Allentown, PA 18106 Mr. John Lancey 1-800-255-4500	Mechanical Welding, Inc. RD #2, Box 29A Peach Bottom, PA 17563 Mr. Lee Ellis (717) 548-2172	

TEXAS

American Inland Marine Pipeline 1901 Central Drive, Suite 201 Bedford, TX 76021 Mr. J. Glenn Phillips (817) 267-0451, 283-1831		

VIRGINIA

Albert J. Anderson, Inc. 10435 Stallworth Court Fairfax, VA 22032 Mr. Albert J. Anderson (703) 425-4795	Thomas H. Andrews, Inc. Box 522 Alexandria, VA 22313 Mr. Andrews (703) 548-5275	Britton Construction, Inc. Box 909 Chincoteague, VA 23336 Mr. Raymond L. Britton, Jr. (804) 336-5500, 336-5916,
Richard E. Callis, Co. box 83 Cobbs Creek, Virginia 23035 Mr. Richard Callis (804) 725-7616	Coastal Design & Construction, Inc. P.O. Box 2159 Newport News, VA 23602 Mr. James Gunn (804) 877-6009	Commercial Marine Services, Inc. 2783 Hartland Road Falls Church, VA 22043 Mr. Richard L. Glenn (703) 849-8633
Fisher & Merritt Const. Co. Willow Street Chincoteague, VA 23336 Mr. B. Fisher (804) 336-5415, 336-5266	G & C Construction Corp. P.O. Box 354 Merrifield, VA 22116 Mr. A. Rey (703) 560-6202	Hardaway Constructors, Inc. P.O. Box 1646 Chesapeake, VA 23320 Mr. Duane R. Church (804) 485-5664

Hult Construction Corp. P.O. Box 97 Chantilly, VA 22021 Mr. Tore M. Hult (703) 968-7100	Johnston Construction Co. 543 Lafayette Street colonial Beach VA 22443 Mr. Richard W. Johnston (804) 224-0202	Lorton Contracting Company 10301 Richmond Highway Lorton, VA 22079 Mr. Manuel Espina (703) 550-9755
Lynnhaven Dredging Co., Inc. 2600 Potters Road Virginia Beach, VA 23452 Mr. J. Reese Smith (804) 486-6699	Marine Contracting Corp. P.O. Box 5525 2430 Ferry Road Virginia Beach, VA 23455 Mr. William Larson (804) 460-4666	The Hull Corporation 1916 Wilson Blvd., Suite 207 Arlington, VA 22201 Mr. William E. James (703) 528-0206
Merit Construction Assocs., Inc. P.O. Box 450 Chantilly, Virginia 22021 Mr. Mark Bailey (703) 471-0148	Melka Marine, Inc. 2851 Meadow View Road Falls Church, VA 22042 Mr. Len Melka (703) 960-3346	Merkli & Lester, Inc. Box 348 Haymarket, VA 22069 Mr. Henry L. Merkli (703) 273-6025
Lake Services P.O. Box 608 212 S. Fraley Blvd. Dumfries, VA 22026 Mr. Mike Sturdvant	Roubin & Janeiro, Inc. P.O. Box 1003 Merifield, VA 22116 Mr. A. S. Roubin (703) 573-9350	Springfield Contracting Corp. 7407 farnum Street Springfield, VA 22151 Mr. Jay Saulsgiver (703) 550-7900
Tebbs Construction Co., Inc. Box 801 Kilmarnock, VA 22482 Mr. Stuart T. Tebbs, Jr. (804) 435-1925	Seascape, Inc. 43 Victoria Drive Warrenton, VA 22186 Mr. Dave Emerick (703) 349-9092	

WASHINGTON, D. C.

Delta Equipment Rental, Inc. 2800 8th Street, N.E. Washington, D. C. 20017 Mr. Howard Beezer (202) 526-2200		

MATERIAL SUPPLIERS

ALUMINUM

Kaiser Aluminum & Chemical Sales P.O. Box 632, Manor Branch New Castle, DE 19720 Mr. Art Wilson (302) 652-1151 (Aluminum Culvert Pipe Only)	Ravens-Metal Products, Inc. P.O. Box 97 Elizabeth, WV 26143 Mr. Barry Hansen (304) 275-4247	Wilton Corporation P.O. box 248 Finksburg, MD 21048 Mr. Michael Pue, Jr. (301) 833-8500
Midas Utility Supply 5101 Sunnyside Avenue College Park, MD 20740 (301) 474-4888		

FILTER CLOTH

A/C Pipe, Inc. P.O. Box 122 Chantilly, VA 22021 Mr. John Bradley (703) 471-0375	American Excelsior Company P.O. Box 25 Annapolis Junction, MD 20701 Mr. Warren Cohen (301) 725-0464	Atlantic Construction Fabrics P.O. Box 427 Chantilly, VA 22193 Mr. Michael Shipley (703) 631-9222
Carthage Mills, Inc. Erosion Control Division 1821 Summit Road Cincinnati, OH 45237 Mr. Frederick Ward (513) 242-2740, (800) 543-4430	Elphinstone, Inc. 1109 Middle River Road Baltimore, MD 21220 Mr. Larry McDonald (301) 686-5100	Merit Supply of Maryland, Inc. P.O. Box 170 11131 Red Lion Road White Marsh, MD 21162 Ms. Christine P. Master, Pres. (301) 335-2828
Sea Port Marine Corp. P.O. Box 2158 Norfolk, VA 23501 Mr. Ben Simmons (804) 545-4631	T.E.I. Construction Fabrics P.O. Box 9652 Baltimore, MD 21237 Mr. John Davis (301) 686-8000	Tri-State Explosives, Inc. P.O. Box 34300 Bethesda, MD 20817 Mr. A. L. White (301) 365-2100
Weems Brothers, Inc. Route 2, Box 161 Trappe, MD 21673 Mr. Edmund W. Weems (301) 822-0510	Wolbert & Master, Inc. P.O. box 292 White Marsh, MD 21162 Mr. Tom Master (301) 335-9300	Form Services, Inc. P.O. Box 60 Linthicum Heights, MD 21090-0060 Mr. Gary Stanton (800) 492-2165

HARDWARE

Stanley C. Flagg & Co. Stowe, PA 19464 Mr. James Trout (215) 326-9000	McCrone Associates, Inc. 1404 Crain Highway, South Glen Burnie, MD 21061 Mr. Ken Collins (301) 768-2300	Sea Port Marine Corp. P.O. Box 2158 Norfolk, VA 23501 Mr. Ben Simmons (800) 446-8056, (804) 446-8056
Chesapeake Wood Products, Inc. 7443 Shipley Avenue Hanover, MD 21076 Mr. Bob Kanode	Form Services, Inc. P.O. Box 60 Linthicum Heights, MD 21090-0060 Mr. Gary Stanton (800) 492-2165	

STONE

The Arundel Corporation 110 West Road Baltimore, MD 21204 Mr. Richard H. Bowden (301) 296-6400	Genstar Stone Products 11350 McCormick Road Hunt Valley, MD 21031 Mr. Leo Schick (301) 628-4000	Maryland Materials, Inc. P.O. Box W North East, MD 21901 Mr. Gene Dean (301) 287-8177
Phoenix, Inc. P.O. Box 676 Frederick, MD 21701 Mr. Gerald W. Blank (301) 663-3151	Rockville Crushed Stone P.O. Box 4407 Rockville, MD 20850 Mr. Alvie Buchanan (301) 762-9307	Stancils, Inc. Mountain Hill Road Perryville, MD 21903 Mr. Terry Stancil (301) 939-2224
D. M. Stoltzfus & Son, Inc. Talmadge, PA 17580 Mr. Mark Arnold (717) 656-2411, (301) 658-5135 (301) 398-1430	Stoneyhurst Quarries, Inc. P.O. Box 34463 Bethesda, MD 20817 Mr. John Stone (301) 365-2274	Cotten Construction Co. P.O. box 4862 Baltimore, MD 21211 Mr. Cusic Q. Cotten (301) 889-4791

TIMBER

Atlantic Creosoting Company P.O. Box 340 Portsmouth, VA 23705 Mr. Ed Monroe (804) 397-2317	Atlantic Wood Industries, Inc. P.O. Box 507 Hainesport, NJ 08036 Mr. Ross Miller (609) 267-4700	Atlantic Wood Industries, Inc. P.O. Box L Fruitland, MD 21826 (301) 749-2034
Burke-Parsons-Bowlby Corporation P.O. Box 86 Goshen, VA 24439 Mr. Israel Redd (703) 997-9251	Eastern MD. Wood Treat. Co., Inc. P.O. Box 155 Federalsburg, MD 21632 Mr. Richard Petti (301) 754-5771	Holly Hill Forest Industries, Inc. P.O. Box 727 Holly Hill, SC 29059 Mr. Robert Hickok (803) 492-7728
F. Scott Jay & Co., Inc. P.O. Box 482 Millersville, MD 21108 Mr. Scott Jay (301) 987-6800	Koppers Company 950 Koppers Building Pittsburgh, PA 15219 Mr. Donald Dickerson (800) 526-6424	Martin Piling & Lumber Co. 1080 Morris Avenue Union, NJ 07083 Mr. P. A. Rechel (201) 354-7996, (212) 349-1444
Moran Lumber Sales, Inc. P.O. box 365 Villanova, PA 19085 Mr. Thomas J. O'Loughlin (215) 687-9595	Rentokil, Inc. Virginia Wood Preserving Div. P.O. Box 9610 Richmond, VA 23228 Mr. Richard Walker (804) 266-0262	Cotten Construction Co. P.O. box 4862 Baltimore, MD 21211 Mr. Cusic Q. Cotten (301) 889-4791
Ridge Marine Sales P.O. Box 37 Ridge, MD 20680 Mr. Les Hill (301) 373-5888	Southern Wood Piedmont Co. P.O. Box 144 Burlington, NJ 08016 Mr. J. E. Snyder (609) 386-1508	Webster Wood Treating Co. Box 566 Cowen, WV 26206 Mr. Larry S. Leslie (304) 226-5615
Wood Preservers, Inc. Box 145 Warsaw, VA 22572 Mr. Leslie Sanders (804) 333-4022	Chesapeake Wood Products, Inc. 7443 Shipley Avenue Hanover, MD 21076 Mr. Bob Kanode	

GABIONS

Maccaferri Gabions, Inc. Governor Lane Blvd., Box 43A Williamsport, MD 21795 Mr. DeLaMea (301) 223-6910		

INTERLOCKING CONCRETE BLOCKS

Atlas Building Systems P.O. Box 245 Marlton, NJ 08052 Mr. Kenneth Ford (609) 767-0884		

OYSTER SHELLS

C. J. Langenfelder & Son, Inc. Stevensville, MD 21666 (301) 643-5575		

SAND

Genesis Masonry Sand Products 1637 East Old Philadelphia Road Elkton, MD 21921 Mr. Dean Crouse (301) 398-8284		

PLASTIC PILE CAPS

Sailing Specialties, Inc. P.O. Box 99 Commerce Avenue Hollywood, MD 20636 (301) 373-2372		

PIPE

A/C Pipe, Inc. Route 609 & Wade Drive Chantilly, VA 22021 Mr. John Bradley (703) 471-0375	Form Services, Inc. P.O. Box 60 Linthicum Heights, MD 21090-0060 Mr. Gary Stanton (800) 492-2165	Norwood of Maryland, Inc. 1450 Grimm Road Severn, MD 21144 Mr. James Foster (301) 551-8880, 247-8205

SEED AND SOD

Barberry Brothers, Inc. 1865 Poole Road Darlington, MD 21034 Mr. L. Michael Barberry (301) 879-3201	Bowen's Farm Supply, Inc. 2550 Riva Road Annaplis, MD 21401 Mr. James Miller, Sr. (301) 224-3340, 841-6626	

STEEL

Salisbury Steel Products, Inc. Boundary Street Salisbury, MD 21801 Mr. Ray Gutierrey	Sea Port Marine Corporation P.O. Box 2158 Norfolk, VA 23501 Mr. Ben Simmons (804) 545-4631	Wilton Corporation P.O. Box 248 Finksburg, MD 21048 Mr. Michael Pue, Jr. (301) 833-8500
Piling, Inc. P.O. Box 1112 Southgate, MI 48195 Mr. Bill Horvath, Jr. (313) 843-2930		

LANDSCAPERS

LANDSCAPERS

Anderson Landscaping Co. 8454 Woodland Road Millersville, MD 21108 Mr. Alvin Anderson (301) 647-6993	Blanchfield Nursery 474 Jumpers Hole Road Severna Park, MD 21146 Mr. Bob Blanchfield (301) 647-9595	Clayton E. Cullison Valley Lee, MD 20692 Mr. Clayton E. Cullison (301) 994-1788
Norman T. Cully & Excavating 811 Best Gate Road Annapolis, MD 21401 Mr. Norman T. Cully (301) 841-6613	Roy W. George, Inc. 216 New Cut Road Severn, MD 21144 Mr. Roy W. George (301) 969-3008	Greenspring Environmental Designs & Contracting, Inc. P.O. Box 935 Brooklandville, MD 21022 Mr. Keith Bowers (301) 337-3659
The Green Touch 4713 Williston Street Baltimore, MD 21229 Mr. Thomas E. Klamp (301) 646-5550	Less is More 888 Marriottsville Road Marriottsville, MD 21104 Mr. Charles Morar (301) 442-1308	Moore's Sod Farms, Inc. P.O. Box 376 Berlin, MD 21811 Mr. Daniel S. Moore, Jr. (301) 641-2177, 641-2122
Francis R. Moreland 813 Main Street Galesville, MD 20765 Mr. Francis R. Moreland (301) 867-3325	R. E. Snyder & Son Old Love Point Road Stevensville, MD 21666 (301) 643-5189	Cotten Construction Co. P.O. Box 4862 Baltimore, MD 21211 Mr. Cusic Q. Cotten (301) 889-4791
Federal Landscape Corp. 20 Hudson Street Annapolis, MD 21401 Ms. Mary C. Brusighan (301) 266-6544		